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COEFUV: A COMPUTER IMPLEMENTATION OF A GENERALIZED UNMANNED VEHICLE COST MODEL

OCTOBER 1978

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In September of 1977, the Directorate of Aerospace Studies (DAS) undertook an analysis to illuminate fundamental differences between manned and ground-launched, recoverable unmanned airborne vehicle operations. The potential to save operating and support (O&S) costs by storing unmanned vehicles and removing them from storage when needed was found to be foremost among the differences. However, the implications of such a difference were not obvious and a detailed analysis was needed before they could be understood. It was found that the biggest shortcoming to such an analysis was the lack of a suitable unmanned vehicle cost methodology. This report documents the results of the efforts of DAS to fill that void by systematizing the calculation of the cost of doing a particular job with unmanned vehicles in a specified period of time. The calculations are based on the most well-developed unmanned vehicle operational concepts currently available. The methodology is unusual because the specific nature of the job to be done by the unmanned vehicles is not of concern. Only the number of sorties needed "on target" and the time to generate them are important.

Many DAS participants supported this effort. The authors wish to acknowledge Richard H. Anderson for the development of the effectiveness equations; Lt Col Winston M. Boyer and James H. Suttle for the development of the cost equations; Captain David K. Forbes for programming assistance; and Dr Kenneth W. Smith for his overall guidance and critical review.

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This document summarizes a method of determining the cost and cost effectiveness of ground-launched, recoverable unmanned airborne vehicle (e.g., remotely piloted vehicle) operations in a tactical environment. The inputs and outputs of a computer code implementing the methodology are described in detail and a listing of the code is presented.

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1. INTRODUCTION

The prediction of costs of future manned aircraft operations, including the personnel, equipment, and facilities required is a procedure backed by decades of experience. The situation for costing future ground-launched, recoverable unmanned vehicle operations is quite different. While a minor amount of experience exists for unmanned vehicle programs based on the Viet Nam conflict and the on-going COMBAT ANGEL program at Davis-Monthan Air Force Base, there is not a generally accepted costing methodology for unmanned vehicles. This is especially true for operations involving large numbers of vehicles for no experience exists in this area. This situation has made a meaningful cost comparison between manned and unmanned vehicles virtually impossible.

In an attempt to rectify this shortcoming for a manned/unmanned vehicle operational comparison, the Directorate of Aerospace Studies (DAS) developed the effectiveness and costing methodology of the COEFUV (<u>CO</u>st <u>EF</u>fectiveness of <u>U</u>nmanned <u>V</u>ehicles) model. The effectiveness methodology addresses a fundamental operational difference between manned and unmanned vehicle operations -- the ability to store unmanned vehicles for long periods of time prior to their use. The costing methodology represents an extensive application of analogy and first order analysis to determine from the most detailed unmanned vehicle operational concepts available the nature of the factors determining unmanned vehicle operational cost. For the costing, the following areas were identified as being characteristic of unmanned vehicles:

1. Vehicle Acquisition.
2. Operating Location.
3. Launch.
4. Recovery.
5. Maintenance.
6. Operations
7. Storage.
8. Training.

Figure 1 shows the fundamental relationship between model inputs, the effectiveness methodology, the costing methodology, and the final product which the model delivers.

The effectiveness and costing relationships for the COEFUV model are discussed in sections 2 and 3, respectively. Section 2 presents a set of equations which relate the mission to be accomplished by the unmanned vehicles, the time available to do the mission, and the number of vehicles required. Section 3 presents the costing equations developed by DAS for the eight cost areas mentioned previously. An equation for each area is given with the definition of each symbol, including the proper dimensions to avoid ambiguity. A brief discussion of each equation is also included.

The executive routine of COEFUV is built around the equations of section 2. The COST subroutine evaluates the equations of section 3 and the INPUT subroutine handles all program input. Program inputs are discussed in section 4. Section 5 illustrates typical inputs with some of the resulting output. The report is concluded with an appendix containing a commented program listing.

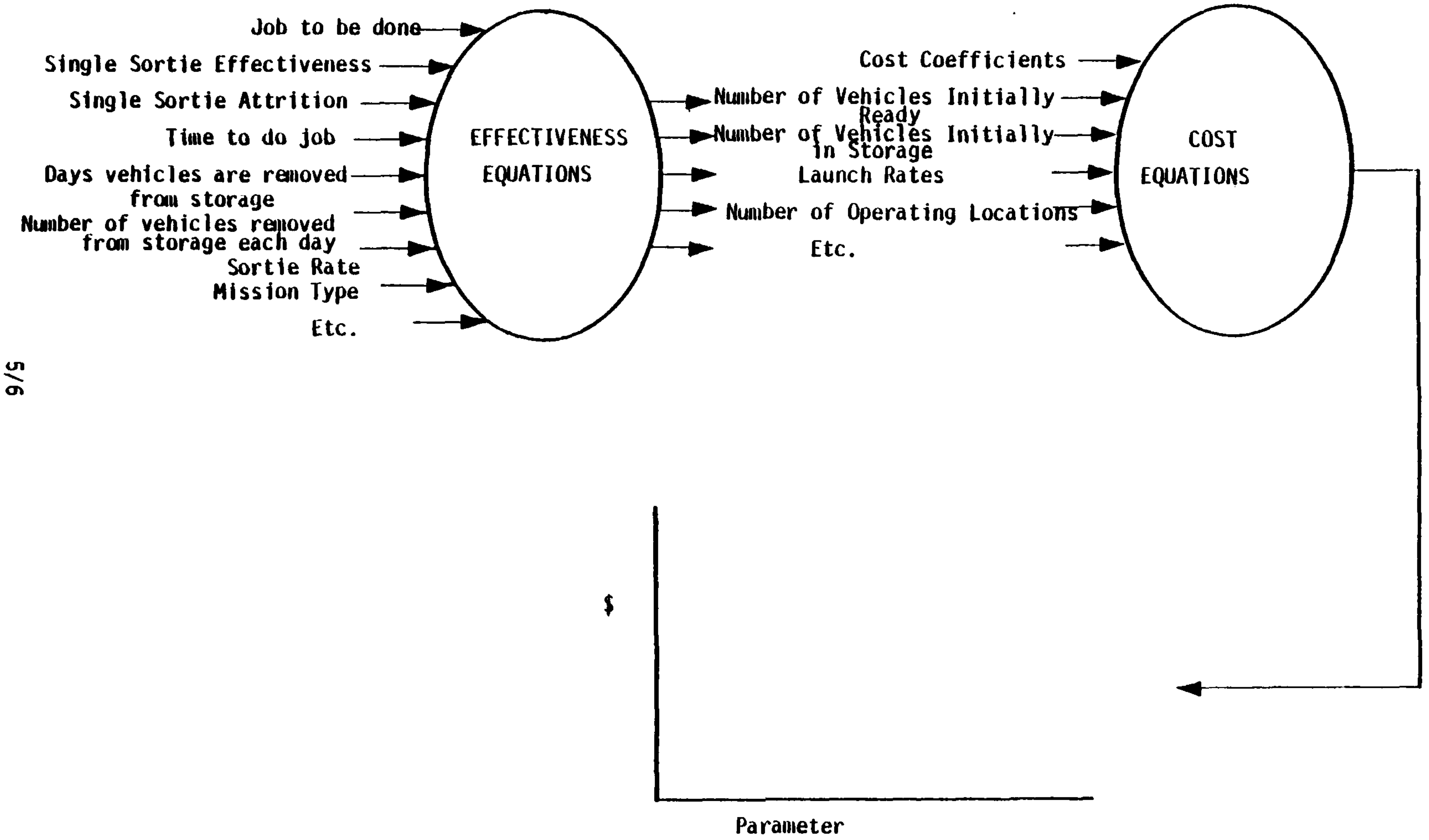

Figure 1. The relationship between major inputs, the effectiveness and cost equations, and the final model product.

2. THE THEORETICAL EQUATIONS

One of the fundamental differences between manned and ground-launched, recoverable unmanned vehicle operations is the potential to keep unmanned vehicles (U/V) in storage prior to the onset of hostilities and to retrieve them from storage as desired. This possibility provides options for the use of unmanned vehicles not available with manned vehicles. These options basically may be characterized by the number of vehicles initially ready to fly and the number initially in storage. The possible configurations run from the extreme of all vehicles initially ready to all vehicles initially in storage. The theory discussed below will treat the implications of these various configurations to the cost of doing a specific task in a fixed time. Two cases will be considered in the following discussion. They will be denoted as the target rich (optimization) case and the constant level of effort case. The computer code implements both.

To facilitate the presentation of the theory, seven basic quantities will be defined initially.

E_0 = the job (mission) to be done, consisting of E_0 subtasks.

d_0 = the number of days in which to do the E_0 subtasks.

ρ = the expected number of the E_0 subtasks done by each successful unmanned vehicle sortie.

A = the single sortie attrition of the unmanned vehicles.

n = the number of vehicles to be retrieved from storage each day.

d_s = the number of days vehicles are to be removed from storage.

r_s = the sortie rate maintained by a ready vehicle while it survives.

With these definitions in mind, consider figure 2. Depicted heuristically in this figure are several time histories of the number of the launches per day

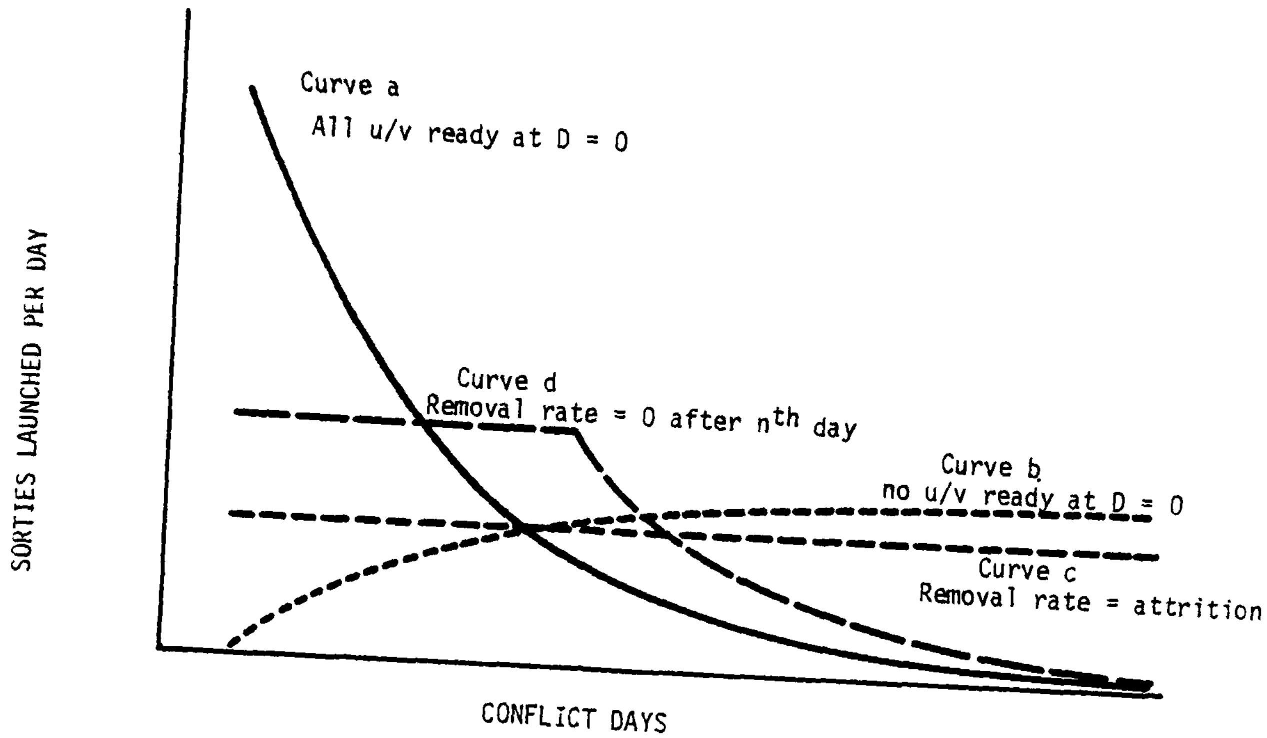

Figure 2. Examples of Time Histories of Launches Per Day for Various Possible Operational Strategies

required in achieving E_o in d_o days. Curve a represents the situation of all vehicles initially ready. On the first day all vehicles are launched and recovered and relaunched repeatedly, as long as they survive,[1] at the sortie rate r_s. On succeeding days, this pattern is repeated, beginning the day with the previous day's survivors. Curve b represents the case in which none of the vehicles are initially ready; all are in storage with n being removed each day. In this case as time progresses, more and more vehicles are ready on each successive day. Curve c represents the critical case of precisely the correct number of vehicles being initially ready that only enough vehicles need be removed from storage each day to replace the attrited vehicles. Finally, curve d depicts the situation where vehicles are withdrawn from storage for only d_s days. In the event that the removal rate from storage just replaces the losses for each of the d_s days as illustrated, then such cases will also be called critical cases.

1. A constant probability of survival is associated with all sorties.

It is obvious that each of these cases potentially has a different cost. The different launch and recovery rates, storage retrieval rates, storage costs, and so forth which are implied strongly indicate different system costs because of differing requirements for personnel, equipment, and facilities. Additionally, each different case will, in general, require a different total number of vehicles with a different acquisition cost. The equations of this section address the total vehicles required in storage (N_s) and in readiness (N_r) on the first day to do E_o in d_o days if η vehicles are retrieved from storage each day for d_s days, beginning the first day. Each ready vehicle is assumed to maintain a sortie rate r_s. Equations giving the maximum required launch rate are also given.[1]

$$N_r = \frac{1}{1-P_s^{r_s d_o}}\left\{\frac{E_o\,(1-P_s)}{\eta P_{s1}P_rP_{c1}} - d_s + P_s^{r_s(d_o-d_s)}\left(\frac{1-P_s^{r_s d_s}}{1-P_s^{r_s}}\right)\right\} \qquad (1)$$

where

$$P_s = P_{1s}^{1/r_s}P_{s1}P_{t1}P_{c1}P_{s2}P_{t2}P_{c2}$$ = single sortie survival probability of a vehicle[2]

and

P_{1s} = the daily probability that a vehicle on the ground or its ground facilities are not destroyed.

P_{s1} = conditional probability that a vehicle survives ingress area defenses given that it reaches the ingress area defenses.

---

1. See Anderson, Richard H., The Effects of Force Augmentation on Launch Rate and Force Size Requirements for Recoverable Vehicles, DAS-WP-79-1, Directorate of Aerospace Studies, Kirtland AFB, NM, Jan 1979, for a complete discussion of the following equations.

2. The reference of footnote 1 does not consider terminal survival separately from area survival in the definition of P_s, and also combines $P_{c1}P_{c2}=P_c$.

P_{s2} = conditional probability that a vehicle survives egress area defenses given that it reaches the egress area defenses.

P_{t1} = conditional probability that a vehicle survives ingress terminal defenses given that it reaches the ingress terminal defenses.

P_{t2} = conditional probability that a vehicle survives egress terminal defenses given that is reaches the egress terminal defenses.

P_{c1} = conditional probability that a vehicle is not lost to a system failure during ingress given that it does not abort and is not destroyed by the ingress defenses.

P_{c2} = conditional probability that a vehicle is not lost to a system failure during egress (= P_{c1}) given that it does not abort and is not destroyed by ingress or egress defenses.

P_r = probability that a vehicle does not abort during ingress.

In the computer code the values of P_{s1} and P_{s2} are calculated from the input quantity PSS which represents the total mission attrition due to area defenses. It is assumed that ingress area attrition is twice egress area attrition whence

$$P_{s1} = \frac{-1 + \sqrt{1 + 8 \times PSS}}{2} \tag{2}$$

$$P_{s2} = \frac{1}{2}(1 + P_{s1}) \tag{3}$$

Similarly, P_{t1} and P_{t2} are calculated from the input quantity TPS representing total mission attrition due to terminal defenses.

$$P_{t1} = \frac{-1 + \sqrt{1 + 8 \times TPS}}{2}$$

$$P_{t2} = \frac{1}{2} (1 + P_{t1})$$

P_{c1} is assumed to be equal to P_{c2}. The product is input as PC.

The number of vehicles required in storage at the start of the war is given by

$$N_s = n \frac{1-P_{1s}^{d_s}}{(1-P_{1s})P_{1s}^{d_s}} \qquad (4)$$

Finally, the maximum number of launches required on a single day is given by

$$L_{max} = \frac{1}{1-P_s} \left\{ N_r (1-P_s^{r_s}) \right\} \qquad (5)$$

in the case that the removal rate from storage is less than or equal to the critical removal rate associated with curve c of figure 1, and by

$$L_{max} = \frac{1}{1 - P_s} \left\{ N_r \; P_s^{r_s d_s} (1 - P_s^{r_s}) + n_s (1 - P_s^{r_s d_s}) \right\} \qquad (6)$$

otherwise. Unless raid size is a factor, the maximum required hourly launch rate may be calculated directly from L_{max} by dividing by the number of hours in an operational day. However, unmanned vehicle employment tactics may require the vehicles to be sent in raids of multiple penetrators. If the launching of the vehicles in a raid is required to take place in a short interval of time, then the implied instantaneous launch rate may exceed the nominal hourly rate. In this case, the higher instantaneous launch rate will be taken as the required hourly launch rate in the evaluation of the cost equations of the next section.

Using these equations, the model distinguishes two cases with regard to the nature of E_0, the job to be done. The first case requires only that E_0 be done in d_0 days. It represents a "target-rich" environment in which a sortie on any day can accomplish ρ of the E_0 subtasks. The second case requires that E_0/d_0 subtasks be accomplished daily for d_0 days, i.e., the job to be done is constant. This second case is identically the critical case associated with curve c of figure 1. These classifications are not truly representative of any mission, but they are a suitable approximation in most instances. For example, strike of fixed targets is represented by the first instance with E_0 representing the number of targets to be killed. Reconnaissance of "located targets" is an example of the second situation. The number of targets to be reconnoitered each day, E_0/d_0, is approximately constant.[1]

2.1 THE CONCEPT AND EQUATIONS FOR COST OPTIMIZATION FOR THE TARGET RICH CASE

For the target rich case, given E_0, d_0, ρ, A, and r_s, there are as many ways of performing E_0 subtasks in d_0 days as there are possible choices of η and d_s. Associated with each choice is a cost. For a given value of d_s the minimum cost can be found approximately by calculating the cost associated with various values of η. Rather than input individual values of η, however, the program automatically varies η from the case of curve a (all vehicles initially ready, $\eta=0$) to the case of curve b (no vehicles initially ready, $\eta = \eta_{max}$) in steps of 0.05 η_{max}. The cost determination is treated in the next section. The value of η_{max} can be found from equation (2) by equating the right side to zero. The result is

$$\eta_{max} = \left(\frac{E_0(1-P_s)}{\rho P_{s1} P_r P_{c1}}\right) \Bigg/ \left(d_s - P_s^{r_s(d_0-d_s)} \left(\frac{1-P_s^{r_s d_s}}{1-P_s^{r_s}}\right)\right) \tag{7}$$

The cost is also evaluated for η corresponding to the critical case (attrition equal to removal rate). This value of η, η_{cr}, often gives the minimum

1. There is no reason to exceed the data reduction capabilities of the intelligence system but there is always pressure for the maximum amount of intelligence possible.

cost. n_{cr} may be found by multiplying equation (1) by $(1-P_s^{r_s})$, the probability of loss of a ready vehicle on the first day assuming a sortie rate of r_s. This gives the losses for the first day, which in the critical case equals n_{cr}. Solving the resulting equation for n_{cr} gives

$$n_{cr} = \frac{E_0(1-P_s)(1-P_s^{r_s})}{\rho P_{s1}P_rP_{c1}(1 + d_s - d_sP_s^{r_s} - P_s^{r_s(d_0-d_s)})} \tag{8}$$

2.2 THE EQUATIONS FOR THE CONSTANT LEVEL OF EFFORT CASE

Assuming the constant rate E_0/d_0 subtasks each day, equation (1) is simplified. This can most readily be seen by considering the job done the first day, viz., $E_0/d_0 = e_0$, and setting $d_0 = 1$. Since e_0 can be done without removing vehicles from storage, $d_s = 0$ and

$$N_r = \frac{1}{1-P_s^{r_s}} \left\{\frac{e_0\,(1-P_s)}{\rho P_{s1}P_rP_{c1}}\right\} = \frac{1}{1-P_s^{r_s}} \left\{\frac{E_0(1-P_s)}{\rho P_{s1}P_rP_{c1}d_0}\right\} \tag{9}$$

In the constant rate case, equation (4) remains unchanged; however, the value of n must be calculated. Since the number of ready vehicles attrited is simply

$$n_{cr} = (1-P_s^{r_s})(N_r) = \frac{E_0(1-P_s)}{\rho P_{s1}P_rP_{c1}d_0} \tag{10}$$

that many vehicles must be removed from storage each day. The same result is obtainable from equation (8) by setting $d_s = d_0 - 1$.

The equations presented allow the total vehicles required to do E_0 in d_0 days to be determined by summing equations (1) and (4) or (9) and (4) in the case of a constant daily job. Additionally, equations (5) and (6) give the maximum launch rate required which is equal to the maximum necessary recovery rate. (Equal launch and recovery rates are desirable from common sense arguments.) This information is necessary input to the cost equations presented in the next section.

3. THE COST EQUATIONS

The COEFUV cost equations for unmanned vehicles are presented in this section. These equations were developed at the Directorate of Aerospace Studies to provide an orderly method for considering all cost elements associated with unmanned vehicles. They are based on the ARPV operational concepts of Boeing and Rockwell, but should be general enough to cover almost any cases of unmanned vehicle operation. The eight areas considered for costing in the model are:

1. Vehicle
2. Operating location (areas not specifically covered elsewhere)
3. Launch
4. Recovery
5. Maintenance
6. Operations
7. Vehicle storage
8. Training

The general form of the equations describing the various areas are:

Vehicle:
COST = [VEHICLES] + [SPARES] + [RDT&E] + [PAYLOAD].

Operating Location:
COST = [SECURITY] + [PAYLOAD STORAGE FACILITIES] + [LOCATION START-UP].

Launch:
COST = [PERSONNEL] + [EQUIPMENT] + [RDT&E].

Recovery, Maintenance, Operations, Storage, Training:
COST = [PERSONNEL] + [FACILITIES] + [EQUIPMENT] + [RDT&E].

Each equation is presented below with a definition of each quantity appearing in it. All equations are based on providing a 10 year cost for the area in question. A very brief discussion of each equation is given to provide assistance in understanding the basis of each term. For clarity and brevity, the equations are presented with their original symbology. The variable names assigned in the program are generally close derivatives of the original symbol. Quantities expressing rates are indicated with a dot symbolizing a derivative. Quantities marked with asterisks are obtained from the evaluation of the theoretical equations discussed in the previous section. Quantities marked with † are calculated from other equations in the program. The derivation of some of these quantities are discussed. The notation $[\,]^+$ designates the next greater integer. It is used in evaluating facility, equipment, and personnel costs in those cases where the amount being purchased must be treated in discrete units. It is part of the methodology of the program to always buy complete equipment sets and facilities whenever a fractional part is indicated. However, the corresponding fractional crews which are indicated are not increased to the next whole crew, but the number of men indicated by the fraction is increased to the next whole man.[1] These choices are not necessarily the most realistic in all situations, but they represent a compromise which appears better than the alternatives.[2] All costs are given in millions of dollars or millions of dollars per unit except the mission payload storage cost which is given in dollars per pound.

A discussion following the presentations of the individual equations indicates the method by which the final cost is assembled in the program.

---

1. This technique is exemplifed by
$[(\text{men/crew})(\text{events/hr}) \div (\text{events/hr/crew})]^+ = [\text{men}]^+$
rather than the alternative
$(\text{men/crew})[(\text{events/hr}) \div (\text{events/hr/crew})]^+ = (\text{men/crew})[\text{crews}]^+$

2. If the crew sizes are small, the nature of the compromise is relatively unimportant since it will not drive costs. If crew sizes are large, then costs will be strongly affected by the compromise adopted, with the one selected seeming the most reasonable to the authors.

3.1 VEHICLE COSTS

$$C_{VT} = [\text{VEHICLES}] + [\text{SPARES}] + [\text{RDT\&E}] + [\text{PAYLOAD}]$$

$$= \left[N_{VT} C_{V1} (N_{VT} + N_{TV})^{\frac{\log\gamma}{\log 2}}\right] + \left[C_{V2} N_{VT}\right] + \left[C_{V3}\right] + \left[C_{V4} N_{VT} + C_{V5} \frac{E_o}{\lambda}\right]$$

where

C_{V1} = theoretical first vehicle unit cost ($M).

C_{V2} = 10-year spare and special maintenance cost per vehicle ($M/vehicle).

C_{V3} = RDT&E cost for vehicles ($M).

C_{V4} = recoverable payload cost per vehicle ($M/vehicle).

C_{V5} = expendable payload cost per sortie ($M/sortie).

E_o = total number of successful events to be accomplished in d_o days (events).

*N_{VT} = total vehicles purchased minus training vehicles (vehicles).

*N_{TV} = number of training vehicles (vehicles).

γ = learning curve slope.

†λ = expected number successful events accomplished per sortie[1] (events/sortie).

---

1. λ is derived from ρ (see section 2) by consideration of attrition.

The first term of the vehicle cost equation gives the cost of the operational vehicles. It does not include the cost of the training vehicles which are accounted for in the training costs. The per vehicle cost is based on a log-linear cumulative average curve[1] which gives the average cost of a vehicle in a buy of x vehicles as

$$\overline{C_n} = ax^b \tag{1}$$

where

x = total vehicles produced.

a = theoretical first vehicle unit cost.

$b = \frac{\log \gamma}{\log 2}$ where γ is the slope of the learning curve

Total cost is generated by multiplying both sides of equation (1) by the number of vehicles being costed, in this case the number of operating vehicles. Note that the x of equation (1) includes the training vehicles since the average cost is based on the total buy.

The payload term embodies the assumption that recoverable payloads are purchased on a one-for-one basis with vehicles and that only enough expendable payloads are purchased to do E_o.

1. A good discussion of learning curve theory is given in Boren, H. E., and H. G. Campbell, Learning-Curve Tables: Volume I, 55-69 Percent Slopes, The Rand Corporation, April 1970, RM-6191-PR.

3.2 OPERATING LOCATION COSTS

$$C_{SU} = \text{[SECURITY]} + \text{[PAYLOAD STORAGE FACILITIES]} + \text{[START-UP]}$$

$$= \left[C_{I1} n_{SEC}\right] + \left[C_{I2} M_{LBS} \frac{E_0}{10^6 \lambda}\right] + \left[C_{I3}\right]$$

where

C_{I1} = 10-year cost per man for security personnel including overhead for command, support, and administrative personnel ($M/man).

C_{I2} = 10-year cost per pound for storing mission payload ($/lb).

C_{I3} = initial cost to start-up one operating location ($M).

n_{SEC} = number of security personnel per operating location (men).

M_{LBS} = pounds of mission payload per sortie (lb).

E_0 = total number of successful subtasks to be accomplished in d_0 days.

† λ = expected number of successful events to be accomplished per sortie (events/sortie).

The operating location costs are composed of costs not more appropriately given in other categories. Each cost is on a per operating location basis.

3.3 LAUNCH COSTS

$$C_L = [\text{PERSONNEL COST}] + [\text{EQUIPMENT COST}] + [\text{RDT\&E}]$$

$$= C_{L1} S \left[\left[\frac{n_{LC}\dot{L}_{max}}{\dot{n}_{LC}}\right]^{+} + \left[\frac{n_{LCC}\dot{L}_{max}}{\dot{n}_{LCC}}\right]^{+} \right] +$$

$$\left[C_{L2}\left[\frac{\dot{L}_{max}}{\dot{i}_e}\right]^{+} + C_{L3}\left[\frac{\dot{L}_{max}}{n_{LS}\dot{i}_e}\right]^{+} + C_{L4}\left[\frac{\dot{L}_{max}}{M_{HE}}\right]^{+} \right] + \left[\frac{C_{L5}}{N_{OL}}\right]$$

where

C_{L1} = 10-year cost per man for launch personnel including overhead for command, support, and administrative personnel ($M/man).

C_{L2} = 10-year cost of ownership of a launcher including spares and redundancy ($M/launcher).

C_{L3} = 10-year cost of ownership of launcher accessories including spares and redundancy ($M/accessory).

C_{L4} = 10-year cost of ownership of a set of mobile launch handling equipment including spares and redundancy ($M/mobile launch handling equipment).

C_{L5} = RDT&E cost for launcher equipment ($M).

n_{LC} = number of people per launch crew (men/crew).

$\dot{n}_{LC}$ = launch rate per launch crew (vehicles/hr/crew).

n_{LCC} = number of people per launch control crew (men/crew).

$\dot{n}_{LCC}$ = vehicle control rate per launch control crew (vehicles/hr/crew).

n_{LS} = number of launchers serviced by each set of launcher accessories (launcher/accessory).

* $\dot{L}_{max}$ = maximum required launch rate per operating location (vehicles/hr).

$\dot{l}_e$ = launch rate per launcher (vehicles/hr/launcher).

M_{HE} = number of vehicles launched per hour per set of mobile launch handling equipment (vehicles/hr/mobile launch handling equipment).

† S = number of shifts of launch personnel per day (shifts/day).

† N_{OL} = number of operating locations.

The equation for launch costs gives the launch costs per operating location. The quantity C_{L5} representing the total RDT&E costs must consequently be divided by the number of operating locations. It should be noted that S, the number of shifts of launch personnel, is normally calculated as

$$S = \max(1, T_o/T_s)$$

where

T_o = number of operating hours per day (input as TO)

and

T_s = number of hours per shift (input as TS).

This formulation is correct in the case where maximum launch rate is established by the job to be done, E_o.[1] However, the maximum launch rate may be established by the need to form a raid in a given time (see the definitions of the inputs RAID and TMASS in section 4). In this case, the instantaneous launch rate required may be higher than the average launch rate dictated by E_o. This causes the program to adjust T_o downward to account for the higher launch rate. This adjustment is noted in the program output and applies also to recovery and operations costing.

3.4 RECOVERY COSTS

$$C_R = [\text{PERSONNEL COST}] + [\text{FACILITY COST}] + [\text{EQUIPMENT COST}] + [\text{RDT\&E}]$$

$$= C_{R1} S \left[\left[\frac{n_{RC}\dot{L}_{max}}{\hat{n}_{RC}}\right]^{+} + \left[\frac{n_{RCC}\dot{L}_{max}}{\hat{n}_{RCC}}\right]^{+}\right] + \left[C_{R2}\left[\frac{\dot{L}_{max}}{\dot{r}_e}\right]^{+}\right] +$$

$$\left[C_{R3}\left[\frac{\dot{L}_{max}}{n_{RS}\dot{r}_e}\right]^{+} + C_{R4}\left[\frac{\dot{L}_{max}}{M_{RE}}\right]^{+}\right] + \left[\frac{C_{R5}}{N_{OL}}\right]$$

where

C_{R1} = 10-year cost per man for recovery personnel including overhead for command, support, and administrative personnel ($M/man).

C_{R2} = 10-year cost of ownership of recovery area ($M/area).

C_{R3} = 10-year cost of ownership of recovery accessories including spares and redundancy ($M/accessory).

---

1. For a job E_O and a particular strategy of removing vehicles from storage to do E_O in d days, there is a corresponding maximum number of launches required on at least one day (see section 2, equations (5) and (6)).

C_{R4} = 10-year cost of ownership of mobile recovery handling equipment including spares and redundancy ($M/mobile recovery handling equipment).

C_{R5} = RDT&E cost for recovery equipment ($M).

n_{RC} = number of people per recovery crew (men/crew).

$\dot{n}_{RC}$ = recovery rate per recovery crew (vehicles/hr/crew).

n_{RCC} = number of people per recovery control crew (men/crew).

$\dot{n}_{RCC}$ = vehicle control rate per recovery control crew (vehicles/hr/crew).

n_{RS} = number of recovery areas serviced by each set of accesories (recovery areas/accessory).

* $\dot{L}_{max}$ = maximum required launch rate per operating location (vehicles/hr).

M_{RE} = number of vehicles per hour serviced per unit of mobile handling equipment (vehicles/hr/mobile recovery handling equipment).

$\dot{r}_e$ = recovery rate per recovery area (vehicles/hr/area).

S = number of shifts.

† N_{OL} = number of operating locations.

As with launch costs, RDT&E recovery costs are input as a total cost and must be divided by the number of operating locations so that they are reflected only once in the final recovery cost. All other aspects of recovery costs are based upon meeting the maximum recovery rate.

3.5 MAINTENANCE COSTS

$$C_M = [\text{PERSONNEL COST}] + [\text{FACILITY COST}] + [\text{EQUIPMENT COST}] + [\text{RDT\&E}]$$

$$= C_{M1} S_M \left[\left[\frac{n_{MC} \dot{L}_{max}}{\dot{n}_{MC}} \right]^+ + \left[\frac{n_{MCR} R_{MR} \dot{L}_{max}}{\dot{n}_{MCR}} \right]^+ \right] + \left[C_{M2} \left[\frac{\dot{L}_{max}}{n_{RF}} \right]^+ \right] +$$

$$\left[C_{M3} \left[\frac{\dot{L}_{max}}{n_{TR}} \right]^+ + C_{M4} \left[\frac{\dot{L}_{max}}{n_{RE}} \right]^+ \right] + \left[\frac{C_{M5}}{N_{OL}} \right]$$

where

C_{M1} = 10-year cost per man for maintenance personnel which includes an overhead factor for command, support, and administrative personnel ($M/man).

C_{M2} = 10-year cost of maintenance facilities to maintain a given launch rate per crew ($M/facility/crew).

C_{M3} = 10-year cost of turnaround equipment for a given turnaround rate per crew, including spares and redundancy ($M/turnaround equipment set/crew).

C_{M4} = 10-year cost of repair equipment to maintain a given repair rate per crew, including spares and redundancy ($M/repair equipment set/crew).

C_{M5} = RDT&E cost for maintenance equipment ($/M).

n_{MC} = number of people per turnaround crew (men/crew).

$\dot{n}_{MC}$ = turnaround rate per turnaround crew (vehicles/hr/crew).

n_{MCR} = number of people per repair crew (men/crew).

$\dot{n}_{MCR}$ = repair rate per repair crew (vehicles/hr/crew).

n_{RE} = number of vehicles/hr in repair serviced by repair equipment set (vehicles/hr/repair equipment set/crew).

n_{RF} = number of vehicles/hr handled per maintenance facility (vehicles/hr/facility/crew).

n_{TR} = number of vehicles/hr in turnaround serviced by turnaround equipment set (vehicles/hr/turnaround equipment set/crew).

* $\dot{L}_{max}$ = maximum required launch rate per operating location (vehicles/hr).

R_{MR} = ratio of returning vehicles needing repair to total returning vehicles.

S_M = number of shifts of maintenance personnel.

Maintenance personnel costs are based on the turnaround and repair functions. Each vehicle recovered must be processed by a turnaround crew before being sent out again. In addition, some vehicles must be repaired before going through turnaround. The fraction of returning vehicles requiring repair is given by R_{MR}. The turnaround and repair functions involve entirely different personnel. The quantity S_M, the number of shifts of maintenance personnel (turnaround and repair) required, is given by

$$S_M = T_m/T_s$$

where

T_m = length of a maintenance day in hours (input as TM).

and

T_s = number of hours per shift (input as TS).

Maintenance facility and equipment costs are based on the quantity of facilities and equipment needed to handle the maximum launch rate.

3.6 OPERATIONS COST

$$C_O = [\text{PERSONNEL COST}] + [\text{FACILITY COST}] + [\text{EQUIPMENT COST}] + [\text{RDT\&E}]$$

$$= \left[C_{01} S \left[\frac{n_{OC} T_c \dot{L}_{max}}{\dot{n}_{OC}}\right]^+\right] + \left[C_{02}\left[\frac{\dot{L}_{max}}{\dot{O}_F}\right]^+\right] + \left[C_{03}\left[\frac{\dot{L}_{max}}{\dot{O}_e}\right]^+\right] + \left[\frac{C_{04}}{N_{OL}}\right]$$

where

C_{01} = 10-year cost per man for operations personnel which includes an overhead factor for command, support, and administrative personnel ($M/man).

C_{02} = 10-year cost of a unit of operations facilities ($M/facility).

C_{03} = 10-year cost of a unit of operations equipment including spares and redundancy ($M/equipment).

C_{04} = RDT&E cost for operations equipment ($M).

n_{OC} = number of people per operations crew (men/crew).

$\dot{n}_{OC}$ = number of vehicles controlled simulataneously per operations crew (vehicles/crew).

* $\dot{L}_{max}$ = maximum required launch rate per operating location (vehicles/hr).

$\dot{O}_e$ = vehicles/hr serviced per unit of operations equipment (vehicles/hr/equipment).

$\dot{O}_F$ = vehicles/hr serviced per unit of operations facility (vehicles/hr/facility).

T_C = average time a vehicle is controlled per sortie (hrs).

† S = number of shifts.

Each vehicle is controlled or monitored for a period after takeoff and prior to landing. It is the job of the operations personnel to perform this function, and the number of people required to do this is used to determine the total number of operations personnel. However, operations people also perform other jobs such as mission planning which must be done in parallel with the control. This fact must be reflected in n_{OC}, the number of people per operations crew.

As with launch, recovery, and maintenance costs, numbers of personnel, facilities, and equipment are determined by the maximum launch rate.

3.7 VEHICLE STORAGE COSTS

$$C_S = \text{[PERSONNEL COST]} + \text{[FACILITY COST]} + \text{[EQUIPMENT COST]} + \text{[RDT\&E]}$$

$$= \left[C_{S1} S_M \left[\frac{n_{SC}\dot{n}_S}{\dot{n}_{SC}}\right]^{+}\right] + \left[\frac{C_{S2}N_{VS}}{N_{OL}} + \frac{C_{S3}N_{VR}}{N_{OL}}\right] + \left[C_{S4}\left[\frac{\dot{n}_S}{\dot{n}_{SC}}\right]^{+}\right] + \left[\frac{C_{S5}}{N_{OL}}\right]$$

where

C_{S1} = 10-year cost per man for storage crew including overhead for command, support, and administrative personnel ($M/man).

C_{S2} = 10-year cost of building to store one vehicle in the "not ready" condition ($M/vehicle).

C_{S3} = 10-year cost of building to store one vehicle in the "ready" condition ($M/vehicle).

C_{S4} = 10-year cost of mobile handling equipment including spares and redundancy for one crew ($M/crew).

C_{S5} = RDT&E cost for vehicle storage ($M).

n_{SC} = number of people per storage retrieval crew (men/crew).

$\dot{n}_{SC}$ = removal rate from storage per storage retrieval crew (vehicles/hr/crew).

* $\dot{n}_S$ = required removal rate per operating location (vehicles/hr).

* N_{OL} = number of operating locations.

* N_{VS} = total vehicles stored at all operating locations (vehicles).

* N_{VR} = total vehicles in ready condition stored at all operating locations (vehicles).

† S_M = number of shifts of maintenance personnel.

The vehicle storage cost equation applies to a single operating location. Costs are based on the maximum rate at which vehicles must be removed from storage and the number of vehicles stored and ready in peacetime. The most demanding requirement for people occurs when vehicles are being removed from storage. Hence, this function drives the personnel cost. Facility cost is dependent upon the cost of facilities required to maintain vehicles either in storage or in a ready condition. Equipment cost like personnel cost is driven by the maximum required rate of removing vehicles from storage.

3.8. TRAINING COST

$$C_T = [\text{PERSONNEL COST}] + [\text{FACILITY COST}] + [\text{EQUIPMENT COST}] + [\text{RDT\&E}]$$

$$= [C_{T1}R_AP_TN_{PT} + C_{T2}P_TN_{PT}] + [C_{OF}\text{FRAC}] +$$

$$[\text{FRAC}(C_{LE} + C_{RE} + C_{ME} + C_{OE}) + N_{TV}C_{V1}(N_{VT} + N_{TV})^{\frac{\log Y}{\log 2}}] + [C_{T3}]$$

where

C_{T1} = 10-year cost per man for instructor personnel including overhead for command, support, and administration ($M/man).

C_{T2} = 10-year cost per man for pipeline trainees including overhead for command, support, and administration, plus the cost of travel to training center and to theater ($M/man).

C_{T3} = RDT&E cost for training ($M).

C_{LE}, C_{RE}, C_{ME}, C_{OE} = cost of launch, recovery, maintenance, and operations equipment per operating location ($M).

C_{OF} = cost of facilities for operations per operating location ($M).

C_{V1} = first unit vehicle cost ($M).

FRAC = ratio of training operating location manning to operating location manning.

γ = learning curve coefficient.

N_{PT} = total number of mission personnel for launch, recovery, maintenance, storage, and operations per operating location (men).

N_{TV} = number of training vehicles purchased (vehicles).

P_T = percent of total manpower in training at one time.

R_A = instructor/student ratio.

The training costs are based generally on the assumption that the training operation is a scaled down version of an actual operating location. This is clearly seen in the facility costs and the first term of the equipment costs where a fraction of the corresponding operating location cost is used. The fraction is simply the ratio of the number of people in training to the number manning an operating location. The personnel cost is based on instructor personnel costs plus student personnel costs including travel. The number of instructors is determined by the instructor/student ratio.

The number of training vehicles purchased is calculated from the equation

$$N_{TV} = \frac{FRAC \times \dot{L}_{max}}{PR} \left[1 + 10\ PL \times TT \times NEX1\right]$$

where

* $\dot{L}_{max}$ = maximum required launch rate per operating location (vehicles/hour).

PR = probability that a vehicle does not abort due to a system failure.

PL = number of training vehicles lost per hour of training vehicles flight (losses/hour).

TT = number of flying hours per training exercise (hours/exercise).

NEX1 = number of training exercises per year (exercises/year).

The 10 which appears accounts for the 10 years which are being costed.

An understanding of the training vehicle cost term may be obtained from the discussion of the vehicle cost equation in section 3.1.

3.9 SYSTEM COST

All the cost equations except those for vehicle and training costs apply to a single operating location. The system cost must take into account the costs for all operating locations. The final cost equation becomes

$$\text{TOTAL COST} = [\text{VEHICLES}] + N_{OL}\Big\{[\text{OPERATING LOCATION}] + [\text{LAUNCH}] + [\text{RECOVERY}] + [\text{MAINTENANCE}] + [\text{OPERATIONS}] + [\text{VEHICLE STORAGE}]\Big\} + [\text{TRAINING}]$$

where N_{OL} is the number of operating locations and the brackets indicate the cost from the equations just discussed.

4. INPUT TO PROGRAM COEFUV

Input to program COEFUV is accomplished entirely by punched cards which are handled by subroutine INPUT. Input cards fall into two groups: those which result in numerical and alphanumerical data on the cards being assigned to variables in the program, and those which control various aspects of program flow with regard to input and output. The former group will be discussed first. In a limited number of instances there will be an interdependence between cards of the two groups. These interdependences will be made clear in the definitions of the input quantities.

4.1 DATA INPUTS

All input to program COEFUV is based upon the function of individual cards or groups of cards being specified by an alphanumeric identifier appearing on the card or the first card of the group. For the data inputs being discussed here, the identifier is used to associate the remaining data on the card or the data on the following cards to the appropriate program variables. This identifier begins in column 1 and is limited to a maximum of 10 characters. It is usually identical to the name of the program variable to be defined. If the input value appears on the card with the identifier, it is read from an E20.8 field beginning in column 11. In those instances when the input values appear on the following cards, the data is read with an 8F10.0 format if numeric and an 8A10 format if alphanumeric.

The inputs constituting this group are defined below. Most of them are related to the cost equations of section 3, a lesser number to the theoretical equations of section 2. In a few cases, the inputs relate to yet other aspects of the program. The use of this last group of inputs should be clear from the definitions. The default value of all numerical data quantities is zero. The case title is preset to blanks. The order of these cards in the input deck is arbitrary except for the associated groups of cards which must appear together in the proper order.

CI1 10-year cost per man for security personnel including overhead for command, support, and administrative personnel ($M/man).

CI2 10-year cost per pound for storing mission payload ($/pound).

CI3 Initial cost to start up one operating location ($M).

CL1 10-year cost per man for launch personnel including overhead for command, support, and administrative personnel ($M/man).

CL2 10-year cost of ownership of a launcher including spares and redundancy ($M/launcher).

CL3 10-year cost of ownership of launcher accessories including spares and redundancy ($M/accessory).

CL4 10-year cost of ownership of a set of mobile launch handling equipment including spares and redundancy ($M/mobile launch handling equipment).

CL5 RDT&E cost for launcher equipment ($M).

CM1 10-year cost per man for maintenance personnel including overhead for command, support, and administrative personnel ($M/man).

CM2 10-year cost of maintenance facilities to maintain a given launch rate per crew ($M/facility/crew).

CM3 10-year cost of turnaround equipment for a given turnaround rate per crew including spares and redundancy ($M/turnaround equipment set/crew).

CM4 10-year cost of repair equipment to maintain a given repair rate per crew including spares and redundancy ($M/repair equipment set/crew).

CM5 RDT&E cost for maintenance equipment ($M).

CO1	10-year cost per man for operations personnel including overhead for command, support, and administrative personnel ($M/man).
CO2	10-year cost of a unit of operations facilities ($M/facility).
CO3	10-year cost of a unit of operations equipment including spares and redundancy ($M/equipment).
CO4	RDT&E cost for operations equipment ($M).
CR1	10-year cost per man for recovery personnel including overhead for command, support, and administrative personnel ($M/man).
CR2	10-year cost of ownership of recovery area ($M/area).
CR3	10-year cost of ownership of recovery accessories including spares and redundancy ($M/accessory).
CR4	10-year cost of ownership of mobile recovery handling equipment including spares and redundancy ($M/mobile recovery handling equipment).
CR5	RDT&E cost for recovery equipment ($M).
CS1	10-year cost per man for storage crew including overhead for command, support, and administration ($M/man).
CS2	10-year cost of building to store one vehicle in the "not ready" condition ($M/vehicle).
CS3	10-year cost of building to store one vehicle in the "ready" condition ($M/vehicle).
CS4	10-year cost of mobile handling equipment including spares and redundancy for one crew ($M/crew).
CS5	RDT&E cost for vehicle storage ($M).

CT1 10-year cost per man for instructor personnel including overhead for command, support, and administration ($M/man).

CT2 10-year cost per man for pipeline trainees including overhead for command, support, and administration, plus the cost of travel to training center and theater ($M/man).

CT3 RDT&E cost for training ($M).

CV1 Theoretical first vehicle unit cost ($M).

CV2 10-year spare and special maintenance cost per vehicle ($M/vehicle).

CV3 RDT&E cost for vehicles ($M).

CV4 Recoverable payload cost per vehicle ($M/vehicle).

CV5 Expendable payload per sortie ($M/sortie).

D For the cost optimization case, the number of days in which to accomplish EO. For the constant level of effort case, the total number of days during each of which EO is to be accomplished.

DS The number of days unmanned vehicles are removed from storage.

EO For the cost optimization case, the total number of subtasks to be dealt with in D days. For the constant level of effort case, the total number of subtasks to be dealt with each day.

GAMMA Learning curve slope for the vehicle cost equation.

INNER Follows a CHGD, CHGDS, CHGEO, CHGA, or CHGRHO card to designate that D, DS, etc., is to be varied in the inner program loop. The number in the data field defines how many values ($\leq$ 50) of the variable are to be read from the following cards with format 8F10.0. (See discussion of CHGD in section 4.2 also.)

LDOTE Launch rate per launcher (vehicles/hour/launcher).

MHE Number of vehicles launched per hour per set of mobile launch handling equipment (vehicles/hour/mobile launch handling equipment).

MINL The minimum number of operating locations allowed by constraints external to the program, e.g., geographic constraints.

MLBS Pounds of mission equipment per sortie (pounds).

MLOL Maximum allowable launch rate per operating location based on considerations exterior to the program (vehicles/hour).

MRE Number of vehicles per hour serviced per unit of mobile handling equipment (vehicle/hour/mobile recovery handling equipment).

NDOTLC Launch rate per launch crew (vehicles/hour/crew).

NDOTLCC Vehicle control rate per launch control crew (vehicles/hour/crew).

NDOTMC Turnaround rate per turnaround crew (vehicles/hour/crew).

NDOTMCR Repair rate per repair crew (vehicles/hour/crew).

NDOTOC Number of vehicles controlled simlultaneously per operation crew (vehicles/crew).

NDOTRC	Recovery rate per recovery crew (vehicles/hour/crew).
NDOTRCC	Vehicle control rate per recovery control crew (vehicles/hour/crew).
NDOTSC	Removal rate from storage per storage retrieval crew (vehicles/hour/crew).
NEX1	Number of full scale training exercises per year.
NI	Number of inner loop variations. (See discussion in section 4.2 also.)
NLC	Number of people per launch crew (men/crew).
NLCC	Number of people per launch control crew (men/crew).
NLS	Number of launchers serviced by each set of launcher accessories (launchers/accessory).
NMC	Number of people per turnaround crew (men/crew).
NMCR	Number of people per repair crew (men/crew).
NO	Number of outer loop variations. (See discussion in section 4.2 also.)
NOC	Number of people per operations crew (men/crew).
NRC	Number of people per recovery crew (men/crew).
NRCC	Number of people per recovery control crew (men/crew).
NRE	Number of vehicles per hour in repair serviced by a repair equipment set (vehicles/hour/repair equipment set/crew).

NRF Number of vehicles per hour handled per maintenance facility (vehicles/hour/facility/crew).

NRS Number of recovery areas serviced by each set of accessories (recovery areas/accessory).

NSC Number of people per storage retrieval crew (men/crew).

NSEC Number of security personnel per operating location (men).

NTR Number of vehicles per hour in turnaround serviced by a turnaround equipment set (vehicles/hour/equipment set).

ODOTE Number of vehicles per hour serviced per unit of operations equipment (vehicles/hour/equipment).

ODOTF Number of vehicles per hour serviced per unit of operations facility (vehicles/hour/facility).

OUTER Follows a CHGD, CHGDS, CHGEO, CGHA, or CHGRHO card to designate that D, DS, etc., is to be varied in the outer program loop. The number in the data field defines how many values (≤ 50) of the variable are to be read from the following cards with format 8F10.0. (See discussion of CHGD, etc., in section 4.2 also.)

PC Probability that a vehicle is not lost on a mission due to a system failure. Contrast with PR.

PL Training vehicles lost per hour of training vehicle flight.

PLS Prelaunch survival probability per day.

PR Probability that a vehicle does not abort due to a system failure. Contrast with PC.

PSS — Total ingress/egress probability of survival relative to area defenses. Note that if attrition is being varied under control of CHGA that PSS has no effect. Both area and terminal attrition are contained in the values following CHGA.

PT — Percent of total operational manpower in training at one time.

RA — Instructor to student ratio used in training costing.

RAID — For the cost optimization case, the desired raid size; automatically set to one for the constant level of effort case.

RDOTE — Recovery rate per recovery area (vehicles/hour/area).

RHO — The number of subtasks dealt with by a single sortie given that it arrives "on target."

RMR — Ratio of returning vehicles needing repair to total returning vehicles.

RS — Vehicle sortie rate (sorties/day).

TC — Average time an unmanned vehicle is under control of an operations controller (hours).

TCYCLE — The number of training cycles per year.

TITLE — Case title. The following card contains the case title which will be read with an 8A10 format.

TM — Length of a maintenance day (hours).

TMASS — The time required to assemble a raid of unmanned vehicles into a group of size RAID (hours).

TO The length of the operational day (hours).

TPS Total ingress/egress probability of survival relative to terminal defenses. Note that if attrition is being varied under control of CHGA that TPS has no effect. Both area and terminal attrition are contained in the values following CHGA.

TS Length of a work shift (hours).

TT Length of a full scale exercise (hours).

TYPE = 1 for the cost optimization case; = 2 for the constant level of effort case.

4.2 CONTROL INPUTS

The control inputs determine printing options, indicate the end of input for cases and for the run, and in five instances specify input options. As with the data inputs, the function of the card is determined by the alphanumeric identifier appearing left justified in columns 1-10. However, unlike the data cards, no other data is associated with the identifier. All but the ENDCASE and ENDJOB identifiers are used to set the values of logical variables within the program. The identifiers occur in pairs with one used to set a variable true and the other false. Five pairs of control inputs are used to specify different printing options. These options are illustrated in section 5 which shows a sample input deck and the corresponding output with all possible print statements employed. Five other pairs of identifiers are used to alter the usual input method for the data inputs D, DS, EO, RHO, and PSS (see definitions above).

D, DS, EO, RHO, and PSS are the pivotal parameters for investigation once the cost inputs have been determined. They may be entered as normal data inputs as discussed earlier, or they may be input as a series of values by use of the CHGD, CHGDS, CHGEO, CHGRHO, or CHGA cards in conjunction with the INNER and OUTER data cards also defined above. When this option is chosen, the program user may input up to 50 values of one or two of the five inputs at once. These values are then selected sequentially in the program by two do-loops, one parameter per do-loop. One do-loop is logically within the other and hence called the inner loop. The program logic is executed once for each value of the parameter assigned to the inner loop. If a parameter is also assigned to the outer loop, the inner loop is completely executed for each value of the outer loop parameter. Thus, if m values of the inner loop parameter are input and n values of the outer loop parameter are input, m times n cases will be evaluated. Return to normal input is achieved by using the CONSTD, CONSTDS, CONSTEO, CONSTRHO, and CONSTA cards.

CHGA Causes the logical program variable CHGA to be set true, which in turn alters the method of inputing PSS. CHGA is false by default. See the discussion in the text above. (See also CONSTA.)

CHGD Causes the logical program variable CHGD to be set true, which in turn alters the method of inputing D. CHGD is false by default. See the discussion in the text above. (See also CONSTD.)

CHGDS Causes the logical program variable CHGDS to be set true, which in turn alters the method of inputing DS. CHGDS is false by default. See the discussion in the text above. (See also CONSTDS.)

CHGEO Causes the logical program variable CHGEO to be set true, which in turn alters the method of inputing EO. CHGEO is false by default. See the discussion in the text above. (See also CONSTEO.)

CHGRHO Causes the logical program variable CHGRHO to be set true, which in turn alters the method of inputing RHO. CHGRHO is false by default. See the discussion in the text above. (See also CONSTRHO.)

CONSTA Causes the logical program variable CHGA to be set false, which in turn alters the method of inputing PSS. CHGA is false by default. See the discussion in the text above. (See also CHGA.)

CONSTD	Causes the logical program variable CHGD to be set false, which in turn alters the method of inputing D. CHGD is false by default. See the discussion in the text above. (See also CHGD.)
CONSTDS	Causes the logical program variable CHGDS to be set false, which in turn alters the method of inputing DS. CHGDS is false by default. See the discussion in the text above. (See also CHGDS.)
CONSTEO	Causes the logical program variable CHGEO to be set false, which in turn alters the method of inputing EO. CHGEO is false by default. See the discussion in the text above. (See also CHGEO.)
CONSTRHO	Causes the logical program variable CHGRHO to be set false, which in turn alters the method of inputing RHO. CHGRHO is false by default. See the discussion in the text above. (See also CHGRHO.)
COSTS	Causes the logical program variable COSTS to be set true, which in turn results in the cost subroutine being exercised and the results printed. COSTS is true by default. (See also NOCOSTS.)
DATA	Causes the logical program variable DAT1 to be set true, which in turn causes the inputs discussed in the previous subsection to be printed for each case. DAT1 is true by default. (See also NODATA.)
DEBUG	Causes the logical program variable DEBUG to be set true, which in turn results in the printing of various intermediate results. DEBUG is false by default. (See also NODEBUG.)
ENDCASE	The last card of each case; used to terminate input for a case.
ENDJOB	The last card of a data deck; used to terminate a run.

NOCOSTS Causes the logical program variable COSTS to be set false, which in turn suppresses cost output. COSTS is true by default. (See also COSTS.)

NODATA Causes the logical program variable DAT1 to be set false, which in turn suppresses printing of the inputs discussed in the previous subsection. DAT1 is true by default. (See also DATA.)

NODEBUG Causes the logical program variable DEBUG to be set false, which in turn suppresses the printing of various intermediate results. DEBUG is false by default. (See also DEBUG.)

NOPRINT Causes the logical program variable PRINT to be set false, which in turn causes the suppression of printing of results for each value of DNS in the cost optimization case. PRINT is true by default. (See also PRINT.)

PRINT Causes the logical program variable PRINT to be set true, which in turn causes the printing of results in the cost optimization case for each value of DNS. PRINT is true by default. (See also NOPRINT.)

PRINTOFF Causes the logical program variable PRTOFF to be set true, which in turn causes the suppression of printing of various intermediate results. PRTOFF is false by default. (See also PRINTON.)

PRINTON Causes the logical program variable PRTOFF to be set false, which in turn causes the printing of various intermediate results. PRTOFF is false by default. (See also PRINTOFF.)

5. SAMPLE INPUTS AND OUTPUTS

This section illustrates some examples of program input and output to assist the user. Pages have been reproduced from a sample cost optimization case (TYPE=1) in figures 3-7 and a sample constant level of effort case (TYPE=2) in figures 8-11.

Figure 3 shows the input values as printed by the program. Inputs are organized by category for easy reference. The symbols < and Γ are used to indicate (1) whether or not specific variables were defined for this case (a corresponding input card actually read) or (2) whether the variable has not been defined at all. The absence of either symbol indicates it was previously defined for another case. This page is printed unless a NODATA card has been read.

Figure 4 shows a summary of some important inputs as well as some intermediate calculations. The name of the output-controlling logical variables are identified in the figure. The variables associated with the DEBUG controlled printout are not discussed in this report. Figure 5 similarly shows the results of intermediate calculations including some designed for debugging. The logical variables controlling the printing of this information are also shown in the figure. Note that the maximum launch rate in this case is determined by the raid size requirements rather than the total launches required per day. The output page depicted in figure 5 immediately precedes the output page depicted in figure 6.

Figure 6 shows one of the pages of intermediate cost results given for various values of η, the retrieval rate of vehicles from storage. This page illustrates the retrieval rate value giving the minimum total cost for doing the input specified job (kill 3000 targets in 15 days). Although not indicated in figures 5 or 6, this retrieval rate corresponds to the critical retrieval rate, η_{CR}. The cost breakout lists all eight cost areas discussed in section 3. The printing of this page is controlled by the logical variable PRINT.

Figure 7 presents the results for the most cost effective option.

The last four figures, 8-11 show similar pages from a TYPE=2 case, the constant level of effort case. For this case there is only one possible retrieval rate, hence only one set of cost figures. Print options are similar to a TYPE=1 case, although there are no DEBUG controlled outputs for a TYPE=2 case.

TEST CASE FOR DOCUMENTATION — DATE: 01/08/79 — TIME: 16.40.01.

VALUES FOR INPUT VARIABLES

* INDICATES THE VARIABLE WAS DEFINED FOR THIS CASE
< INDICATES THE VARIABLE IS UNDEFINED

MISSION REQUIREMENTS/CONSTRAINTS							
* TYPE	1.000	* EO	3000.000	* D	15.000	* DS	14.000
* RHO	2.000	* RAID	10.000	* RS	2.400	* TO	8.000
* TS	8.000	* TM	24.000	* TMASS	.500	* MLOL	85.000
* MINL	3.000						
PROBABILITIES							
* PR	.950	* PLS	.980	* PC	.980	* PSS	1.000
* TPS	1.000						
LAUNCH COST COEFFICIENTS							
* CL1	.188	* CL2	.017	* CL3	1.556	* CL4	.006
* CL5	1.230	* NLC	19.200	* NDOTLC	8.000	* NLCC	3.000
* NDOTLCC	16.000	* LDOTE	1.000	* NLS	16.000	* MHE	.250
RECOVERY COST COEFFICIENTS							
* CR1	.188	* CR2	.457	* CR3	1.476	* CR4	.006
* CR5	1.353	* NRC	4.800	* NDOTRC	6.000	* NRCC	3.000
* NDOTRCC	16.000	* RDOTE	6.000	* NRS	16.000	* MRE	5.000
OPERATIONS COST COEFFICIENTS							
* CO1	.188	* CO2	.893	* NOC	12.000	* NDOTOC	16.000
* TC	.500	* CO3	.216	* ODOTE	16.000	* ODOTF	16.000
* CO4	0.000						
MAINTENANCE COST COEFFICIENTS							
* CM1	.188	* CM2	.376	* CM3	1.515	* CM4	.307
* NMC	57.000	* NDOTMC	8.000	* NTR	2.000	* NRE	8.000
* NRF	8.000	* RMR	1.000	* NMCR	42.000	* NDOTMCR	8.000
* CM5	10.000						
STORAGE COST COEFFICIENTS							
* CS1	.188	* CS2	.006	* CS3	.016	* CS4	.032
* NSC	7.200	* NDOTSC	8.000	* CS5	10.000		
INITIAL STARTUP COST COEFFICIENTS							
* CI1	.188	* CI2	.080	* CI3	1.630	* NSEC	0.000
* MLBS	2500.000						
TRAINING COST COEFFICIENTS							
* CT1	.188	* CT2	.188	* RA	.050	* PT	.333
* PL	.020	* TT	4.000	* NEX1	4.000	* TCYCLE	4.000
* CT3	10.000						
VEHICLE COST COEFFICIENTS							
* CV1	1.044	* CV2	.040	* CV3	123.000	* CV4	.001
* CV5	.004	* GAMMA	.926				

Figure 3. A Sample Input Case for TYPE = 1

```
      TEST CASE FOR DOCUMENTATION                                        DATE: 01/08/79     TIME: 16.40.01.

SORTIE RATE IS  2.4000 SORTIES / DAY


THIS IS A STRIKE MISSION


TARGETS TO BE KILLED            3000.
NUMBER OF DAYS                    15.
SORTIE RATE, SORTIES/DAY           2.4
PROBABILITY OF LAUNCH               .990
PROBABILITY OF SURVIVAL            1.000     PRTOFF
INGRESS PSI                        1.000
OVERALL SURVIVAL PROBABILITY        .972
TARGET KILLS/SORTIE                2.00
RAID SIZE, VEHICLES               10.

        POK         .028215
        PSTRS       .933617
        PSTRSD      .356886
        PSTRSDS     .382262                  DEBUG
        PSRSODS     .933617
        PLSDS       .753642
        LANDA      1.880904
        SL      1595.0

MAXIMUN RETRIEVAL RATE             8.47      PRTOFF
CRITICAL RETRIEVAL RATE            3.00
```

Figure 4. Results of Intermediate Calculations

```
TEST CASE FOR DOCUMENTATION                                                        DATE: 01/08/79      TIME: 16.40.01.

FOR A RETREIVAL RATE OF      2.97  } PRTOFF

          NVT =       94.     NVS =       48.     NVR =       45.      } DEBUG
          SLR =   168.4211    SLAVG =  107.0135   SLMAX =  168.4211

          OPERATING LOCATIONS REQUIRED         3  } PRINT

          LAUNCH RATE DETERMINED BY RAID SIZE (LAUNCHES/HR/OL)                                     21.1 )
          LAUNCH RATE DETERMINED BY MAXIMUM SORTIES REQUIRED/DAY TO DO JOB (LAUNCHES/HR/OL)         4.5 } PRINT
          MAXIMUM LAUNCH RATE REQUIRED (LAUNCHES/DAY/SYSTEM)                                       505.3 )

          HOURS/DAY BASE MUST OPERATE                    1.78 )
          SHIFT LENGTH (HR)-INPUT                        8.00 }  PRINT
          NUMBER OF SHIFTS/DAY RESET TO                  1.00 )
FRAC=      .2498 )
NTV=   .110E+02  } DEBUG
```

Figure 5. Results of More Intermediate Calculations

TEST CASE FOR DOCUMENTATION DATE: 01/08/79 TIME: 16.40.01.

ITERATION 8

	PERSONNEL PER OPERATING LOCATION			EQUIPMENT PER OPERATING LOCATION			FACILITIES PER OPERATING LOCATION		
LAUNCH	LAUNCH	51.	9.59	LAUNCHERS	22.	.37			
	LAUNCH CONTROL	4.	.75	ACCESSORIES	2.	3.11			
				MOBILE EQUIP	85.	.51			
				RDT + E		.41			
RECOVERY	RECOVERY	17.	3.20	RECOVERY AREAS	4.	1.83			
	RECOVERY CONTROL	4.	.75	ACCESSORIES	2.	2.95			
				MOBILE EQUIR	5.	.03			
				RDT + E		.45			
MAINTENANCE	PERSONNEL	33.	6.20	TURNAROUND EQUIP	1.	1.52	MAINT BUILDINGS	1.	.38
	REPAIR PERS	24.	4.51	REPAIR EQUIP	1.	.31			
				RDT + E		3.33			
STORAGE	PERSONNEL	3.	.56	HANDLING EQUIP	1.	.03	COLD STORAGE	16.	.10
				RDT + E		3.33	READY STORAGE	15.	.24
OPERATIONS	PERSONNEL	8.	1.50	CONTROL EQUIP	2.	.43	CONTROL FACILITY	2.	1.79
				RDT + E		0.00			
OL STARTUP	SECURITY	0.	0.00				MISS. FAC ST	4.	.32
							INITIAL ACTIVATION	1.	1.63
** TOTALS PER OL **		144.	27.07			11.09			4.45
** TOTALS FOR ALL OL **		432.	81.22			33.28			13.35
TRAINING	INSTRUCTORS	2.	.38	SPECIAL EQUIP	1.	2.76	TRAINING LOCATION	1.	.45
	TRAINEES	30.	5.64	TRAINING VEHIC	11.	7.32			
				RDT + E		3.33			
VEHICLES				ACQUISITION	94.	58.53			
				SPARES		3.76			
				RDT + E		123.00			
				RECOVERABLE PAYLOAD		.09			
				EXPENDABLE PAYLOAD		6.38			
** TOTALS FOR ENTIRE SYSTEM **		464.	87.23			267.71			13.80
** TOTAL SYSTEM COST **			368.74						

Figure 6. Intermediate Cost Results for η_{CR}

TEST CASE FOR DOCUMENTATION DATE: 01/08/79 TIME: 16.40.01.

THE MOST COST - EFFECTIVE OPTION IS:

ITERATION NUMBER	8.
TOTAL COST	368.74
STORAGE REMOVAL RATE - DNS	3.0
TOTAL VEHICLES - NVT	94.
NUMBER OF READY VEHICLES - NVR	45.
NUMBER OF STORED VEHICLES - NVS	48.
MAX AVERAGE SORTIE RATE - SLAVG	107.0
MAXIMUM SORTIE RATE - SLMAX	168.4
RAID SORTIE RATE - SLR	168.4
NO. OF OPERATING LOCATIONS - NOL	3.

	PERSONNEL REQUIREMENTS FOR THIS OPTION			EQUIPMENT REQUIREMENTS FOR THIS OPTION			FACILITY REQUIREMENTS FOR THIS OPTION		
LAUNCH	LAUNCH	153.	28.76	LAUNCHERS	66.	1.12			
	LAUNCH CONTROL	12.	2.26	ACCESSORIES	6.	9.34			
				MOBILE EQUIP	255.	1.53			
				RDT + E		1.23			
RECOVERY	RECOVERY	51.	9.59	RECOVERY AREAS	12.	5.48			
	RECOVERY CONTROL	12.	2.26	ACCESSORIES	6.	8.86			
				MOBILE EQUIP	15.	.09			
				RDT + E		1.35			
MAINTENANCE	PERSONNEL	99.	18.61	TURNAROUND EQUIP	3.	4.55	MAINT BUILDINGS	3.	1.13
	REPAIR PERS	72.	13.54	REPAIR EQUIP	3.	.92			
				RDT + E		10.00			
STORAGE	PERSONNEL	9.	1.69	HANDLING EQUIP	3.	.10	COLD STORAGE	48.	.29
				RDT + E		10.00	READY STORAGE	45.	.73
OPERATIONS	PERSONNEL	24.	4.51	CONTROL EQUIP	6.	1.30	CONTROL FACILITY	6.	5.36
				RDT + E		0.00			
OL STARTUP	SECURITY	0.	0.00				MISS. FAC ST	12.	.96
							INITIAL ACTIVATION	3.	4.89
TRAINING	INSTRUCTORS	2.	.38	SPECIAL EQUIP	1.	2.76	TRAINING LOCATION	1.	.45
	TRAINEES	30.	5.64	TRAINING VEHIC	11.	7.32			
				RDT + E		10.00			
VEHICLES				ACQUISITION	94.	58.53			
				SPARES		3.76			
				RDT + E		123.00			
				RECOVERABLE PAYLOAD		.09			
				EXPENDABLE PAYLOAD		6.38			
** TOTALS FOR ENTIRE SYSTEM **		464.	87.23			267.71			13.80
** TOTAL SYSTEM COST **			368.74						

Figure 7. The Final Results - The Most Cost Effective Option

TEST CASE FOR DOCUMENTATION — DATE: 01/08/79 — TIME: 16.40.01.

VALUES FOR INPUT VARIABLES

* INDICATES THE VARIABLE WAS DEFINED FOR THIS CASE
< INDICATES THE VARIABLE IS UNDEFINED

MISSION REQUIREMENTS/CONSTRAINTS							
* TYPE	2.000	* EO	10.000	D	15.000	DS	14.000
RHO	2.000	RAID	10.000	RS	2.400	TO	8.000
TS	8.000	TM	24.000	THASS	.500	MLOL	85.000
MINL	3.000						
PROBABILITIES							
PR	.950	PLS	.980	PC	.980	PSS	1.000
TPS	1.000						
LAUNCH COST COEFFICIENTS							
CL1	.188	CL2	.017	CL3	1.556	CL4	.006
CL5	1.230	NLC	19.200	NDOTLC	8.000	NLCC	3.000
NDOTLCC	16.000	LDOTE	1.000	NLS	16.000	MHE	.250
RECOVERY COST COEFFICIENTS							
CR1	.188	CR2	.457	CR3	1.476	CR4	.006
CR5	1.353	NRC	4.800	NDOTRC	6.000	NRCC	3.000
NDOTRCC	16.000	RDOTE	6.000	NRS	16.000	MRE	5.000
OPERATIONS COST COEFFICIENTS							
CO1	.188	CO2	.893	NOC	12.000	NDOTOC	16.000
TC	.500	CO3	.216	ODOTE	16.000	ODOTF	16.000
CO4	0.000						
MAINTENANCE COST COEFFICIENTS							
CM1	.188	CM2	.376	CM3	1.515	CM4	.307
NMC	57.000	NDOTMC	8.000	NTR	2.000	NRE	8.000
NRF	8.000	RMR	1.000	NMCR	42.000	NDOTMCR	8.000
CM5	10.000						
STORAGE COST COEFFICIENTS							
CS1	.188	CS2	.006	CS3	.016	CS4	.032
NSC	7.200	NDOTSC	8.000	CS5	10.000		
INITIAL STARTUP COST COEFFICIENTS							
CI1	.188	CI2	.080	CI3	1.630	NSEC	0.000
MLBS	2500.000						
TRAINING COST COEFFICIENTS							
CT1	.188	CT2	.188	RA	.050	PT	.333
PL	.020	TT	4.000	NEX1	4.000	TCYCLE	4.000
CT3	10.000						
VEHICLE COST COEFFICIENTS							
CV1	1.044	CV2	.040	CV3	123.000	CV4	.001
CV5	.004	GAMMA	.926				

Figure 8. A Sample Input Case for TYPE = 2

DATE: 01/08/79 TIME: 16.40.01.

TEST CASE FOR DOCUMENTATION

SORTIE RATE IS 2.4000 SORTIES / DAY

THIS IS A RECCE MISSION

TARGETS FOR RECCE	10.
NUMBER OF DAYS	15.
SORTIE RATE, SORTIES/DAY	2.4
PROBABILITY OF LAUNCH	.990
PROBABILITY OF SURVIVAL	1.000
INGRESS PS1	1.000
OVERALL SURVIVAL PROBABILITY	.972
TARGETS ACQUIRED/SORTIE	2.00
RAID SIZE, VEHICLES	1.
CRITICAL RETRIEVAL RATE	.15

PRTOFF

Figure 9. Results of Intermediate Calculations

```
TEST CASE FOR DOCUMENTATION                                                              DATE: 01/08/79      TIME: 16.40.01.

FOR A RETREIVAL RATE OF      .15     PRINT

      NVT =        5.      NVS =        2.      NVR =        2.
      SLR =        0.0000  SLAVG =      5.3166  SLMAX =      5.3166                 DEBUG
      (NVT, SLR, SLAVG, AND SLMAX ARE CONSTANT FOR THE RECCE MISSION)

      OPERATING LOCATIONS REQUIRED      3     PRINT

      LAUNCH RATE DETERMINED BY RAID SIZE (LAUNCHES/HR/OL)                                      0.0
      LAUNCH RATE DETERMINED BY MAXIMUM SORTIES REQUIRED/DAY TO DO JOB (LAUNCHES/HR/OL)          .2     PRINT
      MAXIMUM LAUNCH RATE REQUIRED (LAUNCHES/DAY/SYSTEM)                                        5.3

FRAC=     .2498
NTV=   .110E+01     DEBUG
```

Figure 10. Results of More Intermediate Calculations

TEST CASE FOR DOCUMENTATION　　　　DATE: 01/08/79　　　　TIME: 16.40.01.

THE MOST COST - EFFECTIVE OPTION IS:

ITERATION NUMBER	1.
TOTAL COST	196.65
STORAGE REMOVAL RATE - ONS	.2
TOTAL VEHICLES - NVT	5.
NUMBER OF READY VEHICLES - NVR	2.
NUMBER OF STORED VEHICLES - NVS	2.
MAX AVERAGE SORTIE RATE - SLAVG	5.3
MAXIMUM SORTIE RATE - SLMAX	5.3
PAID SORTIE RATE - SLR	0.0
NO. OF OPERATING LOCATIONS - NOL	3.

	PERSONNEL REQUIREMENTS FOR THIS OPTION			EQUIPMENT REQUIREMENTS FOR THIS OPTION			FACILITY REQUIREMENTS FOR THIS OPTION		
LAUNCH	LAUNCH	3.	.56	LAUNCHERS	3.	.05			
	LAUNCH CONTROL	3.	.56	ACCESSORIES	3.	4.67			
				MOBILE EQUIP	3.	.02			
				RDT + E		1.23			
RECOVERY	RECOVERY	3.	.56	RECOVERY AREAS	3.	1.37			
	RECOVERY CONTROL	3.	.56	ACCESSORIES	3.	4.43			
				MOBILE EQUIP	3.	.02			
				RDT + E		1.35			
MAINTENANCE	PERSONNEL	9.	1.69	TURNAROUND EQUIP	3.	4.55	MAINT BUILDINGS	3.	1.13
	REPAIR PERS	9.	1.69	REPAIR EQUIP	3.	.92			
				RDT + E		10.00			
STORAGE	PERSONNEL	9.	1.69	HANDLING EQUIP	3.	.10	COLD STORAGE	2.	.01
				RDT + E		10.00	READY STORAGE	2.	.04
OPERATIONS	PERSONNEL	3.	.56	CONTROL EQUIP	3.	.65	CONTROL FACILITY	3.	2.68
				RDT + E		0.00			
OL STARTUP	SECURITY	0.	0.00				MISS. FAC ST	1.	.05
							INITIAL ACTIVATION	3.	4.89
TRAINING	INSTRUCTORS	1.	.19	SPECIAL EQUIP	1.	1.39	TRAINING LOCATION	1.	.22
	TRAINEES	3.	.56	TRAINING VEHIC	1.	.99			
				RDT + E		10.00			
VEHICLES				ACQUISITION	5.	4.05			
				SPARES		.19			
				RDT + E		123.00			
				RECOVERABLE PAYLOAD		.00			
				EXPENDABLE PAYLOAD		.02			
** TOTALS FOR ENTIRE SYSTEM **		46.	8.65			178.99			9.02

** TOTAL SYSTEM COST ** 196.65

Figure 11. The Final Results

APPENDIX

```
      PROGRAM COEFUV(INPUT,OUTPUT)
C
C     THIS PROGRAM IS USED TO COMPUTE THE SYSTEM OF U/V REQUIRED TO MEET
C     A SPECIFIC EFFECTIVENESS AND THEN TO COMPUTE THE COST OF THE SYSTE
C     M BASED ON DIFFERENT CONCEPTS OF OPERATIONS
C
C
C     THE SPECIFIC EFFECTIVENESS OF THE UV FORCE CAN BE CHARACTERIZED BY
C     THE FOLLOWING
C          TYPE = (1=STRIKE),(2=RECCE),(3=DEFENSE SUPPPESSION)
C          EO=TOTAL EFFECTIVENESS REQUIRED WHICH DEPENDS ON THE MISSION
C                    TYPE
C          RHO=NUMBER OF TASKS ACCOMPLISHED PER SUCCESSFUL SORTIE
C          PSS=SINGLE SORTIE SURVIVAL PROBABILITY OF AN U/V
C          RAID = RAID SIZE
C          RS = INDIVIDUAL VEHICLE SORTIE RATE
C          D = NUMBER OF DAYS AVAILABLE TO ACCOMPLISH MISSION
C
      IMPLICITREAL(L,M,N)
      INTEGER MULT,NOL
      INTEGER NO,NI
      COMMON /CHANGE/ NO,VARYO(50),NI,VARY(50)
      COMMON /INPUTS/ TYPE,EO,D,DS,RHO,RAID,RS,TO,TS,TM,TMASS,M
     1LOL,MINL,DUM1(7),PR,PLS,PC,PSS,TPS,DUM2(15),CL1,CL2,CL3,CL
     24,CL5,NLC,NDOTLC,NLCC,NDOTLCC,LDOTE,NLS,MHE,DUM3(3),CR1,CR2,CR
     33,CR4,CR5,NRC,NDOTRC,NRCC,NDOTRCC,RDOTE,NRS,MRE,DUM4(3),CO1,CO
     42,NOC,NDOTOC,TC,CO3,ODOTE,ODOTF,CO4,DUM5(1),CM1,CM2,CM3,CM4,NMC,N
     5DOTMC,NTR,NRE,NRF,RMR,NMCR,NDOTMCR,CM5,DUM6(7),CS1,CS2,CS3,CS4,
     6NSC,NDOTSC,CS5,DUM7(3),CI1,CI2,CI3,NSEC,MLBS,DUM8(5),CT1,CT2,RA,PT
     7,PL,TT,NEX1,TCYCLE,CT3,DUM9(6),CV1,CV2,CV3,CV4,CV5,GAMMA,DUM10(4)
      COMMON /WORKER/ PC1,PS1,PST,DNS,NVR,NVS,NVT,SLAVG,SLMAX,SLR,NO
     1L,LAMDA,SL,SLRMAX
      COMMON /RESULT/ FOLKS(8,5,2),EQUIP(8,5,2),FACIL(8,5,2)
      COMMON /HEADER/ TITLE(8),TODAY,CLOCK,ITER8
      COMMON /SWITCH/ PRINT,COSTS,DEBUG,DAT1,CHGD,CHGDS,CHGRHO,CHGEO,CHG
     1A,PRTOFF,OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL PRINT,COSTS,DEBUG,DAT1
      LOGICAL CHGD,CHGDS,CHGRHO,CHGEO,CHGA,PRTOFF
      DIMENSION ST(20), FOLKM(8,5,2), EQUIM(8,5,2), FACIM(8,5,2)
C
      NO=NI=1
   10 CALL INPUT
C
C     CONTROL SWITCHES - CONTROL PRINTER SELECTIONS
C
C         SWITCH    PRESET     CONTROLS
C         ------    ------    ------------------------------
C
```

```
C        PRINT       ON      PRINTING OF RESULTS AT EACH ONS ITERATION
C
C        COSTS       ON      CALLS TO SUBROUTINE COST
C
C        DEBUG       OFF     PRINTING OF INTERMEDIATE CALCULATIONS
C
C        DAT1        ON      PRINTING OF VALUES IN COMMON /INPUTS/
C
C        PRTOFF      OFF     SUPPRESSES INTERMEDIATE OUTPUT
C
      IF (PRTOFF) GO TO 20
      PRINT 350, TITLE,TODAY,CLOCK,RS
C
C        CALCULATE RAID LAUNCH RATE
C
   20 CONTINUE
      SLR=RAID*TO/(PR*TMASS)
      SLRMAX=RAID/(TMASS*PR)
      IF (SLRMAX.LE.MLOL) GO TO 30
      PRINT 360, SLRMAX,MLOL
      GO TO 10
C          TYPE = (1=COST OPTIMIZATION),(2=CONSTANT LEVEL OF EFFORT)
C        CALCULATE PROBABILITY OF SUCCESSFUL LAUNCH
C
   30 PC1=SQRT(PC)
C
C        CALCULATE INGRESS SURVIVAL PROBABILITY
C
      PS1=(SQRT(1.0+8.0*PSS)-1.0)*0.5
C
C        TERMINAL SURVIVAL IS TPS, INGRESS TERMINAL SURVIVAL IS TPS1
C
      TPS1=(SQRT(1.0+8.0*TPS)-1.0)*0.5
C
C        TOTAL INGRESS SURVIVAL
C
      PS1=PS1*TPS1
C
C        CALCULATE OVERALL MISSION SURVIVAL PROBABILITY
C
      PST=PC*PSS*PLS**(1.0/RS)
C
C        TOTAL SURVIVAL CONSIDERING TERMINAL DEFENSES
C
      PST=PST*TPS
C
C
C        SET UP LOOP ON VALUE TO BE VARIED
C
      IF (PRTOFF) PRINT 620
```

```
      IF (CHGD) DSAVE=DS
C
C        SET UP OUTER AND INNER LOOPS
C        OUTER LOOP
      DO 340 K2=1,NO
      IF (CHGD.AND.OD) D=VARYO(K2)
      IF (CHGD.AND.OD) PRINT 640, D
      IF (CHGDS.AND.ODS) DS=VARYO(K2)
      IF (CHGDS.AND.ODS) PRINT 650, DS
      IF (CHGRHO.AND.ORHO) RHO=VARYO(K2)
      IF (CHGRHO.AND.ORHO) PRINT 660, RHO
      IF (CHGEO.AND.OEO) EO=VARYO(K2)
      IF (CHGEO.AND.OEO) PRINT 670, EO
      IF (CHGA.AND.OA) A=VARYO(K2)
      IF (CHGA.AND.OA) PRINT 680, A
C
C        INNER LOOP
C
      IF (PRTOFF) PRINT 620
      DO 330 K1=1,NI
C
      IF (CHGD.AND.ID) D=VARY(K1)
      IF (CHGDS.AND.IDS) DS=VARY(K1)
      IF (CHGRHO.AND.IRHO) RHO=VARY(K1)
      IF (CHGEO.AND.IEO) EO=VARY(K1)
      IF (CHGA.AND.IA) A=VARY(K1)
C
C
C          CHECK FOR VARY ATTRITION
      IF (CHGA) 40,50
   40 PS1=SQRT((1.0+8.0*PSS)-1.0)*.5
      PST=PC*PSS*PLS**(1.0/RS)
   50 CONTINUE
C        TEST FOR MISSION TYPE
C
      GO TO (60,150),TYPE
C
C     ///////////////////////
C     /  COST OPTIMIZATION  /
C     ///////////////////////
C
   60 CONTINUE
      IF (PRTOFF) GO TO 70
      PRINT 370
      PRINT 380, EO,D,RS,PC1,PSS,PS1,PST,RHO,RAID
   70 CONTINUE
C
C        CALCULATE BOUNDS ON NS  NS MAX AND NS CRITICAL
C
      POK=1.0-PST
```

```
      PSTRS=PST**RS
      PSTRSD=PST**(RS*D)
      PSTPSDS=PST**(RS*DS)
      PSRSDDS=PST**(RS*(D-DS))
      PLSDS=PLS**DS
      LAMDA=RHO*PSI*PR*PC1
      SL=E0/LAMDA
      IF (DEBUG) PRINT 390, POK,PSTRS,PSTRSD,PSTRSDS,PSRSDDS,PLSDS,LAMDA
     1,SL
      DNSMAX=(E0*POK/LAMDA)/(DS-PSRSDDS*(1.0-PSTRSDS)/(1.0-PSTRS))
      DNSC=E0*POK*(1.0-PSTRS)/(LAMDA*(1.0+DS-DS*PSTRS-PSRSDDS))
      IF (PRTOFF) GO TO 80
      PRINT 400, DNSMAX,DNSC
   80 CONTINUE
C
C         SETUP LOOP ON NS
C
      IF (PRINT) PRINT 410
      CTMIN=1.0E100
      TNS=DNSMAX/20.0
      DNS=0.
      DNSLAST=DNS
      MULT=0
      DO 140 ITER8=1,22
      DNS=MULT*TNS
      IF (DNSLAST.LT.DNSC.AND.DNS.GT.DNSC) GO TO 90
      IF (PRINT) PRINT 420, TITLE,TODAY,CLOCK,DNS
      MULT=MULT+1
      GO TO 100
   90 DNS=DNSC
      IF (PRINT) PRINT 430, TITLE,TODAY,CLOCK,DNS
  100 CONTINUE
C
C         CALCULATE NVS,NVR,NVT
C
      NVR=E0*POK/(LAMDA*(1.0-PSTRSD))-(DS-PSRSDDS*(1.0-PSTRSDS)/(1.0-PST
     1RS))*DNS/(1.0-PSTRSD)
      IF (PLS.EQ.1.0) NVS=DNS*DS
      IF (PLS.NE.1.0) NVS=DNS*(1.0-PLSDS)/(PLSDS*(1.0-PLS))
      NVT=NVR+NVS
C
C         CALCULATE LAUNCH RATE AVERAGE MAXIMUM AND MAXIMUM
C
      IF (DNS.GT.DNSC) GO TO 110
      SLAVG=NVR*(1.0-PSTRS)/POK
      GO TO 120
  110 SLAVG=NVR*PSTRSDS
      SLAVG=SLAVG+DNS*(1.0-PSTRSDS)/(1.0-PSTRS)
      SLAVG=SLAVG*(1.0-PSTRS)/POK
  120 SLMAX=AMAX1(SLAVG,SLR)
```

```
      IF (DEBUG) PRINT 440, NVT,NVS,NVR,SLR,SLAVG,SLMAX
C
C        COMPUTE COSTS
C
      IF (.NOT.COSTS) GO TO 140
      CALL COST (TOTAL)
C
C        STORE DATA
C
      IF (TOTAL.GE.CTMIN) GO TO 140
      CTMIN=TOTAL
      ST(1)=ITER8
      ST(2)=TOTAL
      ST(3)=DNS
      ST(4)=NVT
      ST(5)=NVR
      ST(6)=NVS
      ST(7)=SLAVG
      ST(8)=SLMAX
      ST(9)=SLR
      ST(10)=NOL
      DO 130 I=1,8
      DO 130 J=1,5
      DO 130 K=1,2
      FOLKM(I,J,K)=FOLKS(I,J,K)
      EQUIM(I,J,K)=EQUIP(I,J,K)
  130 FACIM(I,J,K)=FACIL(I,J,K)
  140 DNSLAST=DNS
C
C        THE MOST COST EFFECTIVE SYSTEM IS
C
      IF (.NOT.COSTS) GO TO 10
      GO TO 260
C
C     ////////////////////////////////
C     /  CONSTANT LEVEL OF EFFORT   /
C     ////////////////////////////////
C
  150 CONTINUE
      ITER8=1
      SAVRAID=RAID
      RAID=1.0
      IF (PRTOFF) GO TO 160
      PRINT 450
  160 CONTINUE
C
C         CALCULATE CRITICAL REMOVAL RATE ( DNSC )
C
      PST=PSS*PC*PLS**(1.0/RS)
C
```

```
C         TOTAL SURVIVAL CONSIDERING TERMINAL DEFENSES
C
      PST=PST*TPS
      PS1=(SQRT(1.0+8.0*PSS)-1.0)*0.5
C
C         INGRESS SURVIVAL CONSIDERING TERMINAL DEFENSES
C
      PS1=PS1*TPS1
      IF (CHGA) 170,180
  170 PSS=1-A
      PS1=(SQRT(1.0+8.0*PSS)-1.0)*0.5
      PST=PSS*PC*PLS**(1.0/RS)
  180 CONTINUE
      POK=1.0-PST
      LAMDA=RHO*PS1*PR*PC1
      DS=D-1.0
      PSTRS=PST**RS
      PLSDS=PLS**DS
      SL=E0*D/LAMDA
      IF (PRTOFF) GO TO 190
      PRINT 460, E0,D,RS,PC1,PSS,PS1,PST,RHO,RAID
  190 CONTINUE
      DNSC=E0*POK/LAMDA
      IF (PRTOFF) GO TO 200
      PRINT 470, DNSC
  200 CONTINUE
C
C           CALCULATE THE LAUNCH RATE AVERAGE MAXIMUM AND MAXIMUM
C           FOR THE RECCE MISSION SLR AND SLAVG ARE CONSTANTS
C
      SLAVG=E0/LAMDA
      SLR=0
      SLRMAX=0
      SLMAX=SLAVG
      DNS=DNSC
      IF (PRINT) PRINT 420, TITLE,TODAY,CLOCK,DNS
C
C     CALCULATE NVS, NVR, NVT
C
      NVR=E0*POK/((1.0-PSTRS)*LAMDA)
      NVS=DNS*(1.0-PLSDS)/(PLSDS*(1.0-PLS))
      NVT=NVR+NVS
      IF (.NOT.PRINT) GO TO 210
      PRINT 440, NVT,NVS,NVR,SLR,SLAVG,SLMAX
      PRINT 480
C
C         COMPUTE COSTS
C
  210 IF (.NOT.COSTS) GO TO 230
      CALL COST (TOTAL)
```

```
C
C          STORE DATA
C
      CTMIN=TOTAL
      ST(1)=ITER8
      ST(2)=TOTAL
      ST(3)=DNS
      ST(4)=NVT
      ST(5)=NVR
      ST(6)=NVS
      ST(7)=SLAVG
      ST(8)=SLMAX
      ST(9)=SLR
      ST(10)=NOL
      DO 220 I=1,8
      DO 220 J=1,5
      DO 220 K=1,2
      FOLKM(I,J,K)=FOLKS(I,J,K)
      EQUIM(I,J,K)=EQUIP(I,J,K)
  220 FACIM(I,J,K)=FACIL(I,J,K)
  230 CONTINUE
      RAID=SAVRAID
C
C          THE MOST COST EFFECTIVE SYSTEM IS
C
      IF (.NOT.COSTS) GO TO 10
C
C     //////////////////////////////////
C     /  PRINT MINIMUM COST RESULTS  /
C     //////////////////////////////////
C
  260 CONTINUE
      IF (PRTOFF) GO TO 270
      PRINT 520, TITLE,TODAY,CLOCK,(ST(I),I=1,10)
      NOL=ST(10)
      PRINT 530
      PRINT 540, FOLKM(1,1,1),FOLKM(1,1,2),EQUIM(1,1,1),EQUIM(1,1,2),FOL
     1KM(1,2,1),FOLKM(1,2,2),EQUIM(1,2,1),EQUIM(1,2,2),EQUIM(1,3,1),EQUI
     2M(1,3,2),CLS
      PRINT 550, FOLKM(2,1,1),FOLKM(2,1,2),EQUIM(2,1,1),EQUIM(2,1,2),FOL
     1KM(2,2,1),FOLKM(2,2,2),EQUIM(2,2,1),EQUIM(2,2,2),EQUIM(2,3,1),EQUI
     2M(2,3,2),CRS
      PRINT 560, FOLKM(3,1,1),FOLKM(3,1,2),EQUIM(3,1,1),EQUIM(3,1,2),FAC
     1IM(3,1,1),FACIM(3,1,2),FOLKM(3,2,1),FOLKM(3,2,2),EQUIM(3,2,1),EQUI
     2M(3,2,2),CMS
      PRINT 570, FOLKM(4,1,1),FOLKM(4,1,2),EQUIM(4,1,1),EQUIM(4,1,2),FAC
     1IM(4,1,1),FACIM(4,1,2),CSS,FACIM(4,2,1),FACIM(4,2,2)
      PRINT 580, FOLKM(5,1,1),FOLKM(5,1,2),EQUIM(5,1,1),EQUIM(5,1,2),FAC
     1IM(5,1,1),FACIM(5,1,2),CO4
      PRINT 590, FOLKM(6,1,1),FOLKM(6,1,2),FACIM(6,1,1),FACIM(6,1,2),FAC
```

```
     1IM(6,2,1),FACIM(6,2,2)
      PRINT 600, FOLKM(7,1,1),FOLKM(7,1,2),EQUIM(7,1,1),EQUIM(7,1,2),FAC
     1IM(7,1,1),FACIM(7,1,2),FOLKM(7,2,1),FOLKM(7,2,2),EQUIM(7,2,1),EQUI
     2M(7,2,2),CT3
      PRINT 610, EQUIM(8,1,1),EQUIM(8,1,2),EQUIM(8,2,2),EQUIM(8,3,2),EQU
     1IM(8,4,2),EQUIM(8,5,2)
  270 CONTINUE
C
C     COMPUTE TOTALS
C
      NPERS=PERSC=0.0
      DO 280 I=1,8
      DO 280 J=1,5
      NPERS=NPERS+FOLKM(I,J,1)
  280 PERSC=PERSC+FOLKM(I,J,2)
      EQUPC=0.0
      DO 290 I=1,8
      DO 290 J=1,5
  290 EQUPC=EQUPC+EQUIM(I,J,2)
      EQUPC=EQUPC+CLS+CR5+CS5+C04+CT3+CM5
      FACLC=0.0
      DO 300 I=1,8
      DO 300 J=1,5
  300 FACLC=FACLC+FACIM(I,J,2)
      TOTAL=PERSC+EQUPC+FACLC
      IF (PRTOFF) GO TO 310
      PRINT 510, NPERS,PERSC,EQUPC,FACLC,TOTAL
  310 CONTINUE
      IF (.NOT.PRTOFF) GO TO 320
      ST(1)=TOTAL
      ST(2)=EO/RHO
      IF (TYPE.EQ.2) ST(2)=(EO*D)/RHO
      ST(3)=TOTAL*RHO/EO
      IF (TYPE.EQ.2) ST(3)=TOTAL*RHO/(EO*D)
      ST(4)=EO
      IF (TYPE.EQ.2) ST(4)=EO*D
      ST(5)=RHO
      ST(6)=1.0-PSS
      ST(7)=TOTAL*RHO
      PRINT 630, (ST(I),I=1,7)
  320 CONTINUE
C
C        END INNER LOOP K1
  330 CONTINUE
C
C        END OUTER LOOP K2
  340 CONTINUE
C
      IF (CHGD) DS=DSAVE
      GO TO 10
```

```
C
  350 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/16H-SORTIE RA
     1TE IS ,F7.4,14H SORTIES / DAY///)
  360 FORMAT (43HIMAX RAID LAUNCH RATE EXCEEDS OL CAPABILITY,T50,9HSLRMA
     1X = ,F8.2/T50,9HMLOL =    ,F8.2)
  370 FORMAT (25H THIS IS A STRIKE MISSION///)
  380 FORMAT (21H TARGETS TO BE KILLED,T30,F10.0//15H NUMBER OF DAYS,T30
     1,F10.0//25H SORTIE RATE, SORTIES/DAY,T30,F11.1//22H PROBABILITY OF
     2 LAUNCH,T30,F13.3//24H PROBABILITY OF SURVIVAL,T30,F13.3//12H INGR
     3ESS PS1,T30,F13.3//29H OVERALL SURVIVAL PROBABILITY,T30,F13.3//20H
     4 TARGET KILLS/SORTIE,T30,F12.2//20H RAID SIZE, VEHICLES,T30,F10.0/
     5/)
  390 FORMAT (T10,3HPOK,T20,F8.6/T10,5HPSTRS,T20,F8.6/T10,6HPSTRSD,T20,F
     18.6/T10,7HPSTRSDS,T20,F8.6/T10,7HPSRSDDS,T20,F8.6/T10,5HPLSDS,T20,
     2F8.6/T10,5HLAMDA,T20,F8.6/T10,2HSL,T15,F8.1/)
  400 FORMAT (23H MAXIMUM RETRIEVAL RATE,T30,F12.2//24H CRITICAL RETRIEV
     1AL RATE,T30,F12.2)
  410 FORMAT (1H1)
  420 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/25H-FOR A RET
     1REIVAL RATE OF ,F8.2/)
  430 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/25H-FOR A RET
     1RIEVAL RATE OF ,F8.2,10X,43H( ( (   C R I T I C A L    R A T E
     2) ) )/)
  440 FORMAT (T10,5HNVT =,F9.0,T30,5HNVS =,F9.0,T50,5HNVR =,F9.0/T10,5HS
     1LR =,F13.4,T30,7HSLAVG =,F11.4,T50,7HSLMAX =,F11.4)
  450 FORMAT (24H THIS IS A RECCE MISSION///)
  460 FORMAT (19H TARGETS FOR RECCE,T30,F10.0//15H NUMBER OF DAYS,T30,F1
     10.0//25H SORTIE RATE, SORTIES/DAY,T30,F11.1//22H PROBABILITY OF LA
     2UNCH,T30,F13.3//24H PROBABILITY OF SURVIVAL,T30,F13.3//12H INGRESS
     3 PS1,T30,F13.3//29H OVERALL SURVIVAL PROBABILITY,T30,F13.3//24H TA
     4RGETS ACQUIRED/SORTIE,T30,F12.2//20H RAID SIZE, VEHICLES,T30,F10.0
     5//)
  470 FORMAT (24H CRITICAL RETRIEVAL RATE,T30,F12.2)
  480 FORMAT (T10,63H(NVT, SLR, SLAVG, AND SLMAX ARE CONSTANT FOR THE RE
     1CCE MISSION))
  490 FORMAT (38H THIS IS A DEFENSE SUPPRESSION MISSION///)
  500 FORMAT (22H THIS IS AN EW MISSION///)
  510 FORMAT (1X,135(1H-)/31H ** TOTALS FOR ENTIRE SYSTEM **,T34,F7.0,F1
     12.2,T78,F16.2,T119,F16.2//24H ** TOTAL SYSTEM COST **,T37,F16.2)
  520 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/37H-THE MOST
     1COST - EFFECTIVE OPTION IS://T5,16HITERATION NUMBER,T42,F4.0/T5,10
     2HTOTAL COST,T33,F15.2/T5,26HSTORAGE REMOVAL RATE - DNS,T41,F6.1/T5
     3,20HTOTAL VEHICLES - NVT,T38,F8.0/T5,30HNUMBER OF READY VEHICLES -
     4 NVR,T38,F8.0/T5,31HNUMBER OF STORED VEHICLES - NVS,T38,F8.0/T5,31
     5HMAX AVERAGE SORTIE RATE - SLAVG,T38,F9.1/T5,27HMAXIMUM SORTIE RAT
     6E - SLMAX,T38,F9.1/T5,22HRAID SORTIE RATE - SLR,T38,F9.1/T5,32HNO.
     7 OF OPERATING LOCATIONS - NOL,T41,F5.0)
  530 FORMAT (/T17,38HPERSONNEL REQUIREMENTS FOR THIS OPTION,T58,38HEQUI
     1PMENT REQUIREMENTS FOR THIS OPTION,T99,37HFACILITY REQUIREMENTS FO
     2R THIS OPTION/T17,38(1H-),T58,38(1H-),T99,38(1H-))
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540 FORMAT (7H LAUNCH,T19,6HLAUNCH,T37,F4.0,F12.2,T60,9HLAUNCHERS,T78,
   1F4.0,F12.2/T19,14HLAUNCH CONTROL,T37,F4.0,F12.2,T60,11HACCESSORIES
   2,T78,F4.0,F12.2/T60,12HMOBILE EQUIP,T78,F4.0,F12.2/T60,7HROT + E,T
   382,F12.2)
550 FORMAT (9H0RECOVERY,T19,8HRECOVERY,T37,F4.0,F12.2,T60,14HRECOVERY
   1AREAS,T78,F4.0,F12.2/T19,16HRECOVERY CONTROL,T37,F4.0,F12.2,T60,11
   2HACCESSORIES,T78,F4.0,F12.2/T60,12HMOBILE EQUIP,T78,F4.0,F12.2/T60
   3,7HROT + E,T82,F12.2)
560 FORMAT (12H0MAINTENANCE,T19,9HPERSONNEL,T35,F6.0,F12.2,T60,16HTURN
   1AROUND EQUIP,T78,F4.0,F12.2,T101,15HMAINT BUILDINGS,T119,F4.0,F12.
   22/T19,11HREPAIR PERS,T35,F6.0,F12.2,T60,12HREPAIR EQUIP,T78,F4.0,F
   312.2/T60,7HROT + E,T82,F12.2)
570 FORMAT (8H0STORAGE,T19,9HPERSONNEL,T37,F4.0,F12.2,T60,14HHANDLING
   1EQUIP,T78,F4.0,F12.2,T101,12HCOLD STORAGE,T116,F7.0,F12.2/T60,7HRO
   2T + E,T82,F12.2,T101,13HREADY STORAGE,T116,F7.0,F12.2)
580 FORMAT (11H0OPERATIONS,T19,9HPERSONNEL,T37,F4.0,F12.2,T60,13HCONTR
   1OL EQUIP,T78,F4.0,F12.2,T101,16HCONTROL FACILITY,T119,F4.0,F12.2/T
   260,7HROT + E,T82,F12.2)
590 FORMAT (11H0OL STARTUP,T19,8HSECURITY,T37,F4.0,F12.2,T101,14HMISS.
   1 FAC STOR,T113,F10.0,F12.2/T101,18HINITIAL ACTIVATION,T119,F4.0,F1
   22.2)
600 FORMAT (9H0TRAINING,T19,11HINSTRUCTORS,T37,F4.0,F12.2,T60,13HSPECI
   1AL EQUIP,T78,F4.0,F12.2,T101,17HTRAINING LOCATION,T119,F4.0,F12.2/
   2T19,8HTRAINEES,T35,F6.0,F12.2,T60,17HTRAINING VEHICLES,T74,F8.0,F1
   32.2/T60,7HROT + E,T82,F12.2)
610 FORMAT (9H0VEHICLES,T60,11HACQUISITION,T74,F8.0,F12.2/T60,6HSPARES
   1,T80,F14.2/T60,7HROT + E,T80,F14.2/T60,19HRECOVERABLE PAYLOAD,T80,
   2F14.2/T60,18HEXPENDABLE PAYLOAD,T80,F14.2)
620 FORMAT (//T16,4HCOST,T41,6HEO/RHO,T58,8HC RHO/EO,T70,2HEO,T87,3HRH
   1O,T102,4HATTR,T116,5HR RHO)
630 FORMAT (T10,F12.2,T35,F12.3,T50,F12.3,T65,F12.2,T80,F12.2,T95,F12.
   13,T110,F12.2)
640 FORMAT (/T10,14H OUTER LOOP D=,F10.1)
650 FORMAT (/T10,15H OUTER LOOP DS=,F10.1)
660 FORMAT (/T10,16H OUTER LOOP RHO=,F10.2)
670 FORMAT (/T10,15H OUTER LOOP EO=,F10.1)
680 FORMAT (/T10,14H OUTER LOOP A=,F10.3)
    END
```

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      SUBROUTINE INPUT
      COMMON /CHANGE/ NO,VARYO(50),NI,VARY(50)
      COMMON /INPUTS/ TYPE,EO,D,DS,RHO,RAID,RS,TO,TS,TM,TMASS,M
     1LOL,MINL,DUM1(7),PR,PLS,PC,PSS,TPS,DUM2(15),CL1,CL2,CL3,CL
     24,CL5,NLC,NDOTLC,NLCC,NDOTLCC,LDOTE,NLS,MHE,DUM3(3),CR1,CR2,CR
     33,CR4,CR5,NRC,NDOTRC,NRCC,NDOTRCC,RDOTE,NRS,MRE,DUM4(3),CO1,CO
     42,NOC,NDOTOC,TC,CO3,ODOTE,ODOTF,CO4,DUM5(1),CM1,CM2,CM3,CM4,NMC,N
     5DOTMC,NTR,NRE,NRF,RMR,NMCR,NDOTMCR,CM5,DUM6(7),CS1,CS2,CS3,CS4,
     6NSC,NDOTSC,CS5,DUM7(3),CI1,CI2,CI3,NSEC,MLBS,DUM8(5),CT1,CT2,RA,PT
     7,PL,TT,NEX1,TCYCLE,CT3,DUM9(6),CV1,CV2,CV3,CV4,CV5,GAMMA,DUM10(4)
      COMMON /RESULT/ FOLKS(8,5,2),EQUIP(8,5,2),FACIL(8,5,2)
      COMMON /HEADER/ TITLE(8),TODAY,CLOCK,ITER8
      COMMON /SWITCH/ PRINT,COSTS,DEBUG,DAT1,CHGD,CHGDS,CHGRHO,CHGEO,CHG
     1A,PRTOFF,OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL PRINT,COSTS,DEBUG,DAT1
      LOGICAL CHGD,CHGDS,CHGRHO,CHGEO,CHGA,PRTOFF
      DIMENSION VAR(145), NAMES(145), FLAG(145)
      EQUIVALENCE (VAR(1),TYPE)
C
C     MISSION REQUIREMENTS
C
      DATA (NAMES(I),I=1,20)/4HTYPE,2HEO,1HD,2HDS,3HRHO,4HRAID,2HRS,
     12HTO,2HTS,2HTM,5HTMASS,4HMLOL,4HMINL,7*7H$UNUSED/
C
C      PROBABILITIES
C
      DATA (NAMES(I),I=21,40)/2HPR,3HPLS,2HPC,3HPSS,3HTPS,15*7H$UNUSED/
C
C     LAUNCH COST COEFFICIENTS
C
      DATA (NAMES(I),I=41,55)/3HCL1,3HCL2,3HCL3,3HCL4,3HCL5,3HNLC,6HNDOT
     1LC,4HNLCC,7HNDOTLCC,5HLDOTE,3HNLS,3HMHE,3*7H$UNUSED/
C
C     RECOVERY COST COEFFICIENTS
C
      DATA (NAMES(I),I=56,70)/3HCR1,3HCR2,3HCR3,3HCR4,3HCR5,3HNRC,6HNDOT
     1RC,4HNRCC,7HNDOTRCC,5HRDOTE,3HNRS,3HMRE,3*7H$UNUSED/
C
C     OPERATIONS COST COEFFICIENTS
C
      DATA (NAMES(I),I=71,80)/3HCO1,3HCO2,3HNOC,6HNDOTOC,2HTC,3HCO3,5HOD
     1OTE,5HODOTF,3HCO4,7H$UNUSED/
C
C     MAINTENANCE COST COFFFICIENTS
C
      DATA (NAMES(I),I=81,100)/3HCM1,3HCM2,3HCM3,3HCM4,3HNMC,6HNDOTMC,3H
     1NTR,3HNRE,3HNRF,3HRMR,4HNMCR,7HNDOTMCR,3HCM5,7*7H$UNUSED/
C
C     STORAGE COST COEFFICIENTS
```

```
C
      DATA (NAMES(I),I=101,110)/3HCS1,3HCS2,3HCS3,3HCS4,3HNSC,6HNDOTSC,3
     1HCS5,3*7H$UNUSED/
C
C     INITIAL STARTUP COST COEFFICIENTS
C
      DATA (NAMES(I),I=111,120)/3HCI1,3HCI2,3HCI3,4HNSEC,4HMLBS,5*7H$UNU
     1SED/
C
C     TRAINING COST COEFFICIENTS
C
      DATA (NAMES(I),I=121,135)/3HCT1,3HCT2,2HRA,2HPT,2HPL,2HTT,4HNEX1,6
     1HTCYCLE,3HCT3,6*7H$UNUSED/
C
C     VEHICLE COST COEFFICIENTS
C
      DATA (NAMES(I),I=136,145)/3HCV1,3HCV2,3HCV3,3HCV4,3HCV5,5HGAMMA,4*
     17H$UNUSED/
      DATA FLAG/145*1H</,VAR/145*0.0/
      DATA PRINT,COSTS,DEBUG,DAT1,CHGD,CHGDS,CHGRHO,CHGEO,CHGA,PRTOFF/.T
     1RUE.,.TRUE.,.FALSE.,.TRUE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.
     2,.FALSE./
      DATA OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA/.FALSE.,.FALSE.,.FALSE.
     1,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.FALSE./
      DATA TITLE/8*1H /
      ISTOP=1
      PRINT 340
      CALL DATE (TODAY)
      CALL TIME (CLOCK)
      DO 10 I=1,145
   10 IF (FLAG(I).EQ.1H<) FLAG(I)=1H
   20 READ 350, NAME,DATA
      IF (NAME.EQ.10HENDJOB    ) STOP
      IF (NAME.EQ.10H          ) GO TO 20
      IF (NAME.EQ.10HPRINT     ) GO TO 40
      IF (NAME.EQ.10HNOPRINT   ) GO TO 50
      IF (NAME.EQ.10HCOSTS     ) GO TO 60
      IF (NAME.EQ.10HDATA      ) GO TO 100
      IF (NAME.EQ.10HNODATA    ) GO TO 110
      IF (NAME.EQ.10HNOCOSTS   ) GO TO 70
      IF (NAME.EQ.10HDEBUG     ) GO TO 80
      IF (NAME.EQ.10HNODEBUG   ) GO TO 90
      IF (NAME.EQ.10HTITLE     ) GO TO 120
      IF (NAME.EQ.10HENDCASE   ) GO TO 290
      IF (NAME.EQ.10HCHGD      ) GO TO 140
      IF (NAME.EQ.10HCONSTD    ) GO TO 140
      IF (NAME.EQ.10HCHGDS     ) GO TO 160
      IF (NAME.EQ.10HCONSTDS   ) GO TO 160
      IF (NAME.EQ.10HCHGRHO    ) GO TO 180
      IF (NAME.EQ.10HCONSTRHO  ) GO TO 180
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      IF (NAME.EQ.10HCHGEO      ) GO TO 200
      IF (NAME.EQ.10HCONSTEO    ) GO TO 200
      IF (NAME.EQ.10HCHGA       ) GO TO 220
      IF (NAME.EQ.10HCONSTA     ) GO TO 220
      IF (NAME.EQ.10HPRINTOFF   ) GO TO 230
      IF (NAME.EQ.10HPRINTON    ) GO TO 240
      DO 30 I=1,145
      IF (NAME.EQ.NAMES(I)) GO TO 280
   30 CONTINUE
      PRINT 360, ISTOP,NAME,DATA
      PRINT 370
      ISTOP=0
      GO TO 20
   40 PRINT=.TRUE.
      GO TO 20
   50 PRINT=.FALSE.
      GO TO 20
   60 COSTS=.TRUE.
      GO TO 20
   70 COSTS=.FALSE.
      GO TO 20
   80 DEBUG=.TRUE.
      GO TO 20
   90 DEBUG=.FALSE.
      GO TO 20
  100 DAT1=.TRUE.
      GO TO 20
  110 DAT1=.FALSE.
      GO TO 20
  120 READ 380, TITLE
      GO TO 20
  130 CHGD=.TRUE.
      GO TO 250
  140 CHGD=.FALSE.
      IF (OD) NO=1
      IF (ID) NI=1
      OD=.FALSE.
      ID=.FALSE.
      IF (NAME.EQ.10HCHGD       ) GO TO 130
      GO TO 20
  150 CHGDS=.TRUE.
      GO TO 250
  160 CHGDS=.FALSE.
      IF (ODS) NO=1
      ODS=.FALSE.
      IF (IDS) NI=1
      IDS=.FALSE.
      IF (NAME.EQ.10HCHGDS      ) GO TO 150
      GO TO 20
  170 CHGRHO=.TRUE.
```

```
      GO TO 250
  180 CHGRHO=.FALSE.
      IF (ORHO) NO=1
      ORHO=.FALSE.
      IF (IRHO) NI=1
      IRHO=.FALSE.
      IF (NAME.EQ.10HCHGRHO     ) GO TO 180
      GO TO 20
  190 CHGEO=.TRUE.
      GO TO 250
  200 CHGEO=.FALSE.
      IF (OEO) NO=1
      OEO=.FALSE.
      IF (IEO) NI=1
      IEO=.FALSE.
      IF (NAME.EQ.10HCHGEO      ) GO TO 190
      GO TO 20
  210 CHGA=.TRUE.
      GO TO 250
  220 CHGA=.FALSE.
      IF (OA) NO=1
      OA=.FALSE.
      IF (IA) NI=1
      IA=.FALSE.
      IF (NAME.EQ.10HCHGA       ) GO TO 210
      GO TO 20
  230 PRTOFF=.TRUE.
      GO TO 20
  240 PRTOFF=.FALSE.
      GO TO 20
  250 READ 350, NAME,DATA
      IF (NAME.EQ.10HOUTER      ) GO TO 260
      IF (NAME.EQ.10HINNER      ) GO TO 270
      PRINT 390, NAME
      ISTOP=0
      GO TO 20
  260 CONTINUE
      NO=DATA
      IF (CHGD.AND..NOT.ID) OD=.TRUE.
      IF (CHGDS.AND..NOT.IDS) ODS=.TRUE.
      IF (CHGRHO.AND..NOT.IRHO) ORHO=.TRUE.
      IF (CHGEO.AND..NOT.IEO) OEO=.TRUE.
      IF (CHGA.AND..NOT.IA) OA=.TRUE.
      READ 400, (VARYO(I),I=1,NO)
      PRINT 410, (VARYO(I),I=1,NO)
      GO TO 20
  270 CONTINUE
      NI=DATA
      IF (CHGD.AND..NOT.OD) ID=.TRUE.
      IF (CHGDS.AND..NOT.ODS) IDS=.TRUE.
```

```
      IF (CHGRHO.AND..NOT.ORHO) IRHO=.TRUE.
      IF (CHGEO.AND..NOT.OEO) IEO=.TRUE.
      IF (CHGA.AND..NOT.OA) IA=.TRUE.
      READ 400, (VARY(I),I=1,NI)
      PRINT 420, (VARY(I),I=1,NI)
      GO TO 20
  280 VAR (I)=DATA
      FLAG(I)=1H*
      GO TO 20
  290 IF (.NOT.DAT1) GO TO 300
      PRINT 430, TITLE,TODAY,CLOCK
      PRINT 440
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=1,13)
      PRINT 450
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=21,25)
      PRINT 460
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=41,52)
      PRINT 470
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=56,67)
      PRINT 480
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=71,79)
      PRINT 490
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=81,93)
      PRINT 500
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=101,107)
      PRINT 510
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=111,115)
      PRINT 520
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=121,129)
      PRINT 530
      PRINT 550, (FLAG(I),NAMES(I),VAR(I),I=136,141)
  300 DO 310 I=1,8
      DO 310 J=1,5
      DO 310 K=1,2
  310 FOLKS(I,J,K)=EQUIP(I,J,K)=FACIL(I,J,K)=0.0
      IF (ISTOP.EQ.0) GO TO 330
      IF (DAT1) RETURN
      DO 320 I=1,145
      IF (FLAG(I).EQ.1H*) PRINT 540, NAMES(I),VAR(I)
  320 CONTINUE
      RETURN
  330 CONTINUE
      PRINT 560
      STOP *-  INPUT ERRORS*
C
  340 FORMAT (1H1)
  350 FORMAT (A10,E20.8)
  360 FORMAT (I1,9X,A10,5X,F10.3)
  370 FORMAT (1H+,T40,46H****  VARIABLE NAME IS NOT IN DICTIONARY  ****)
  380 FORMAT (8A10)
```

```
390 FORMAT (T10,A10,T25,33HIS NOT INNER OR OUTER INPUT ERROR)
400 FORMAT (8F10.0)
410 FORMAT (T10,24HOUTER LOOP VALUES VARIED/(8F12.3))
420 FORMAT (T10,24HINNER LOOP VALUES VARIED/(8F12.3))
430 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/27H0VALUES FO
   1R INPUT VARIABLES,T40,51H>  INDICATES THE VARIABLE WAS DEFINED FOR
   2 THIS CASE/T40,38H<  INDICATES THE VARIABLE IS UNDEFINED)
440 FORMAT (33H0MISSION REQUIREMENTS/CONSTRAINTS)
450 FORMAT (14H0PROBABILITIES)
460 FORMAT (25H0LAUNCH COST COEFFICIENTS)
470 FORMAT (27H0RECOVERY COST COEFFICIENTS)
480 FORMAT (29H0OPERATIONS COST COEFFICIENTS)
490 FORMAT (30H0MAINTENANCE COST COEFFICIENTS)
500 FORMAT (26H0STORAGE COST COEFFICIENTS)
510 FORMAT (34H0INITIAL STARTUP COST COEFFICIENTS)
520 FORMAT (27H0TRAINING COST COEFFICIENTS)
530 FORMAT (26H0VEHICLE COST COEFFICIENTS)
540 FORMAT (T10,A10,F10.3)
550 FORMAT (4X,A2,A10,F10.3,15X,A2,A10,F10.3,15X,A2,A10,F10.3,15X,A2,A
   110,F10.3)
560 FORMAT (16H0ERRORS IN INPUT)
    END
```

```
      SUBROUTINE COST (TOTAL)
C
C        THIS ROUTINE CALCULATES THE SYSTEM COST BASED ON THE REQUIRED
C        LAUNCH RATES AND NUMBER OF VEHICLES-TOTAL,IN STORAGE AND READY
C
C        COSTS ARE DIVIDED INTO EIGHT TASK AREAS:  LAUNCH, RECOVERY,
C        MAINTENANCE, STORAGE, OPERATIONS, STARTUP, TRAINING, AND
C        VEHICLE ACQUISITION
C
C     RESULTS FROM THE COST EQUATIONS ARE PLACED IN THE ARRAYS
C        FOLKS(8,5,2)     PERSONNEL REQUIREMENTS
C        EQUIP(8,5,2)     EQUIPMENT REQUIREMENTS
C        FACIL(8,5,2)     FACILITIES REQUIREMENTS
C
C     THE SUBSCRIPTS FOR THESE ARRAYS ARE ARRANGED AS FOLLOWS:
C        ARRAY(TASK,SUBTASK,UNITS), WHERE
C
C              TASK = 1    LAUNCH
C                     2    RECOVERY
C                     3    MAINTENANCE
C                     4    STORAGE
C                     5    OPERATIONS
C                     6    OPERATING LOCATION STARTUP
C                     7    TRAINING
C                     8    VEHICLE ACQUISITION
C
C                 SUBTASK = 1,N    FOR THE SUB-PORTIONS OF THE
C                                  COST ESTIMATING RELATIONSHIP
C
C                       UNITS = 1    NUMBER REQUIRED
C                               2    COST
C
C
      IMPLICITREAL(L,M,N)
      COMMON /INPUTS/ TYPE,EO,D,DS,RHO,RAID,RS,TO,TS,TM,TMASS,M
     1LOL,MINL,DUM1(7),PR,PLS,PC,PSS,TPS,DUM2(15),CL1,CL2,CL3,CL
     24,CL5,NLC,NDOTLC,NLCC,NDOTLCC,LDOTE,NLS,MHE,DUM3(3),CR1,CR2,CR
     33,CR4,CR5,NRC,NDOTRC,NRCC,NDOTRCC,RDOTE,NRS,MRE,DUM4(3),CO1,CO
     42,NOC,NDOTOC,TC,CO3,ODOTE,ODOTF,CO4,DUM5(1),CM1,CM2,CM3,CM4,NMC,N
     5DOTMC,NTR,NRE,NRF,RMR,NMCR,NDOTMCR,CM5,DUM6(7),CS1,CS2,CS3,CS4,
     6NSC,NDOTSC,CS5,DUM7(3),CI1,CI2,CI3,NSEC,MLBS,DUM8(5),CT1,CT2,RA,PT
     7,PL,TT,NEX1,TCYCLE,CT3,DUM9(6),CV1,CV2,CV3,CV4,CV5,GAMMA,DUM10(4)
      COMMON /WORKER/ PC1,PS1,PST,DNS,NVR,NVS,NVT,SLAVG,SLMAX,SLR,NO
     1L,LAMDA,SL,SLRMAX
      COMMON /RESULT/ FOLKS(8,5,2),EQUIP(8,5,2),FACIL(8,5,2)
      COMMON /HEADER/ TITLE(8),TODAY,CLOCK,ITER8
      COMMON /SWITCH/ PRINT,COSTS,DEBUG,DAT1,CHGD,CHGDS,CHGRHO,CHGEO,CHG
     1A,PRTOFF,OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL OD,ODS,ORHO,OEO,OA,ID,IDS,IRHO,IEO,IA
      LOGICAL PRINT,COSTS,DEBUG,DAT1
```

```
      LOGICAL CHGD,CHGDS,CHGRHO,CHGEO,CHGA,PRTOFF
      INTEGER NOL
      ROUND(ARG)=AINT(ARG+0.99999999999999)
C
C        CALCULATE NUMBER OF OPERATING LOCATION REQUIRED
C          MLOL = MAXIMUM LAUNCH RATE PER OPERATING LOCATION
C          NOL = NUMBER OF OPERATING LOCATION
C
      NOL=MAX1(ROUND(SLAVG/(TO*MLOL)),MINL)
      IF (PRINT) PRINT 90, NOL
C
C        COMPUTE THE NUMBER OF SHIFTS
C
      SAVESLX=SLMAX
      SSLMAX=SLAVG/(TO*NOL)
      SLMAX=SLAVG
      IF (SLRMAX.GT.SSLMAX) SLMAX=SLR*NOL
      IF (PRINT) PRINT 100, SLRMAX,SSLMAX,SLMAX
      S=TO/TS
      S=AMAX1(1.,S)
      SM=TM/TS
      IF (SLRMAX.GT.SSLMAX) 10,20
   10 TIME=(SLAVG*TMASS/(NOL*RAID))
      S=AMAX1(1.,TIME/TS)
      IF (PRINT) PRINT 110, TIME,TS,S
   20 CONTINUE
C
C     ///////////////////
C     /  LAUNCH COSTS  /
C     ///////////////////
C
      DL=SLMAX/(TO*NOL)
C
C     LAUNCHERS
C
      EQUIP(1,1,1)=ROUND(DL/LDOTE)
      EQUIP(1,1,2)=CL2*EQUIP(1,1,1)
C
C     LAUNCH PERSONNEL
C
      FOLKS(1,1,1)=S*ROUND(NLC*DL/NDOTLC)
      FOLKS(1,1,2)=CL1*FOLKS(1,1,1)
C
C     LAUNCH CONTROL PERSONNEL
C
      FOLKS(1,2,1)=S*ROUND(NLCC*DL/NDOTLCC)
      FOLKS(1,2,2)=CL1*FOLKS(1,2,1)
C
C     LAUNCHER ACCESSORIES
C
```

```
      EQUIP(1,2,1)=ROUND(DL/(NLS*LDOTE))
      EQUIP(1,2,2)=CL3*EQUIP(1,2,1)
C
C     MOBILE LAUNCH HANDLING EQUIPMENT
C
      EQUIP(1,3,1)=ROUND(DL/MHE)
      EQUIP(2,2,1)=ROUND(DL/(NRS*RDOTE))
      EQUIP(1,3,2)=CL4*EQUIP(1,3,1)
C
C     /////////////////////
C     /  RECOVERY COSTS  /
C     /////////////////////
C
      DL=SLMAX/(TO*NOL)
C
C     RECOVERY AREAS
      EQUIP(2,1,1)=ROUND(DL/RDOTE)
      EQUIP(2,1,2)=CR2*EQUIP(2,1,1)
C
C     RECOVERY PERSONNEL
C
      FOLKS(2,1,1)=S*ROUND(NRC*DL/NDOTRC)
      FOLKS(2,1,2)=CR1*FOLKS(2,1,1)
C
C     RECOVERY CONTROL PERSONNEL
C
      FOLKS(2,2,1)=S*ROUND(NRCC*DL/NDOTRCC)
      FOLKS(2,2,2)=CR1*FOLKS(2,2,1)
C
C     RECOVERY ACCESSORIES
C
      EQUIP(2,2,1)=ROUND(DL/NRS)
      EQUIP(2,2,2)=CR3*EQUIP(2,2,1)
C
C     MOBILE RECOVERY HANDLING EQUIPMENT
C
      EQUIP(2,3,1)=ROUND(DL/MRE)
      EQUIP(2,3,2)=CR4*EQUIP(2,3,1)
C
C     ////////////////////////
C     /  MAINTENANCE COSTS  /
C     ////////////////////////
C
C        CALCULATE AVERAGE LAUNCH RATE
C
      DL=SLAVG/(TM*NOL)
C
C     MAINTENANCE PERSONNEL
C
      FOLKS(3,1,1)=SM*ROUND(NMC*DL/NDOTMC)
```

```
      FOLKS(3,1,2)=CM1*FOLKS(3,1,1)
      FOLKS(3,2,1)=SM*ROUND(NMCR*DL*RMR/NDOTMCR)
      FOLKS(3,2,2)=FOLKS(3,2,1)*CM1
C
C     MAINTENANCE FACILITIES AND EQUIPMENT
C
      EQUIP(3,1,1)=ROUND(DL/NTR)
      EQUIP(3,2,1)=ROUND(DL/NRE)
      EQUIP(3,1,2)=CM3*EQUIP(3,1,1)
      EQUIP(3,2,2)=CM4*EQUIP(3,2,1)
C
      FACIL(3,1,1)=ROUND(DL/NRF)
      FACIL(3,1,2)=CM2*FACIL(3,1,1)
C
C     ////////////////////
C     /  STORAGE COSTS  /
C     ////////////////////
C
      NDOTS=DNS/(NOL*TM)
C
C     STORAGE PERSONNEL
C
      FOLKS(4,1,1)=ROUND(SM*ROUND(NSC*NDOTS/NDOTSC))
      FOLKS(4,1,2)=CS1*FOLKS(4,1,1)
C
C     STORAGE EQUIPMENT
C
      EQUIP(4,1,1)=ROUND(NDOTS/NDOTSC)
      EQUIP(4,1,2)=CS4*EQUIP(4,1,1)
C
C     STORAGE FACILITIES
C
      FACIL(4,1,1)=NVS/NOL
      FACIL(4,1,2)=CS2*FACIL(4,1,1)
      FACIL(4,2,1)=NVR/NOL
      FACIL(4,2,2)=CS3*FACIL(4,2,1)
C
C     ///////////////////////
C     /  OPERATIONS COSTS  /
C     ///////////////////////
C
      DL=SLMAX/(TO*NOL)
C
C     OPERATIONS PERSONNEL
C
      FOLKS(5,1,1)=S*ROUND(NOC*DL*TC/NDOTOC)
      FOLKS(5,1,2)=CO1*FOLKS(5,1,1)
C
C     OPERATIONS EQUIPMENT
C
```

```
      EQUIP(5,1,1)=ROUND(DL/ODOTE)
      EQUIP(5,1,2)=CO3*EQUIP(5,1,1)
C
C     OPERATIONS FACILITIES
C
      FACIL(5,1,1)=ROUND(DL/ODOTF)
      FACIL(5,1,2)=CO2*FACIL(5,1,1)
C
C     ///////////////////////
C     /  OL STARTUP COSTS  /
C     ///////////////////////
C
C     SECURITY PERSONNEL
C
      FOLKS(6,1,1)=NSEC
      FOLKS(6,1,2)=CI1*FOLKS(6,1,1)
C
C     STORAGE FACILITIES
C
      FACIL(6,1,1)=MLBS*SL/1.0E6
      FACIL(6,1,2)=CI2*FACIL(6,1,1)
C
C     STARTUP
C
      FACIL(6,2,1)=1.0
      FACIL(6,2,2)=CI3*FACIL(6,2,1)
C
C     /////////////////////
C     /  TRAINING COSTS  /
C     /////////////////////
C
C     NOTE:  THE COST OF TRAINING VEHICLES IS NOT COMPUTED
C            UNTIL THE UNIT VEHICLE COST IS KNOWN.
C
      NPT=FOLKS(1,1,1)+FOLKS(1,2,1)+FOLKS(2,1,1)+FOLKS(2,2,1)+FOLKS(3,1,
     11)+FOLKS(5,1,1)+FOLKS(4,1,1)
      NPT=NPT*NOL/TCYCLE
      FRAC=AMIN1(1.0,PT*NOL/TCYCLE)
      IF (DEBUG) PRINT 120, FRAC
C
C     INSTRUCTORS
C
      FOLKS(7,1,1)=ROUND(RA*PT*NPT)
      FOLKS(7,1,2)=CT1*FOLKS(7,1,1)
C
C     TRAINEES
C
      FOLKS(7,2,1)=ROUND(PT*NPT)
      FOLKS(7,2,2)=CT2*FOLKS(7,2,1)
C
```

```
C     TRAINING FACILITIES
C
      FACIL(7,1,1)=1.0
      FACIL(7,1,2)=FRAC*FACIL(5,1,2)
C
C     EQUIPMENT
C
      EQUIP(7,1,1)=1.0
      EQUIP(7,1,2)=FRAC*(EQUIP(1,1,2)+EQUIP(1,2,2)+EQUIP(1,3,2)+EQUIP(2,
     11,2)+EQUIP(2,2,2)+EQUIP(2,3,2)+EQUIP(3,1,2))+FRAC*(EQUIP(3,2,2)+EQ
     2UIP(5,1,2))
C
C     TRAINING VEHICLES
C
      TEMP=AMAX1(RAID,SLAVG/(TO*NOL))
      NTV=FRAC*TEMP/PR
      NTV=NTV*(1.+10.*PL*TT*NEX1)
      EQUIP(7,2,1)=NTV
      IF (DEBUG) PRINT 130, NTV
C
C     /////////////////////////////////
C     /  VEHICLE ACQUISITION COSTS  /
C     /////////////////////////////////
C
C     ACQUISITION
C
      EQUIP(8,1,1)=NVT
      TEMP=CV1*(NVT+NTV)**(ALOG(GAMMA)/ALOG(2.))
      EQUIP(8,1,2)=NVT*TEMP
C
C        COMPUTE COST OF TRAINING VEHICLES
      EQUIP(7,2,2)=NTV*TEMP+CV2*NTV
C
C     SPARES
C
      EQUIP(8,2,2)=CV2*EQUIP(8,1,1)
C
C     RDT + E
C
      EQUIP(8,3,2)=CV3
C
C     PAYLOADS
C
      EQUIP(8,4,2)=CV4*EQUIP(8,1,1)
      EQUIP(8,5,2)=CV5*EO/LAMDA
C
C
C     ////////////////////
C     /  PRINT RESULTS  /
C     ////////////////////
```

```
C
      IF (.NOT.PRINT) GO TO 40
      PRINT 140, TITLE,TODAY,CLOCK,ITER8
      PRINT 150
      PRINT 160, FOLKS(1,1,1),FOLKS(1,1,2),EQUIP(1,1,1),EQUIP(1,1,2),FOL
     1KS(1,2,1),FOLKS(1,2,2),EQUIP(1,2,1),EQUIP(1,2,2),EQUIP(1,3,1),EQUI
     2P(1,3,2),CL5/NOL
      PRINT 170, FOLKS(2,1,1),FOLKS(2,1,2),EQUIP(2,1,1),EQUIP(2,1,2),FOL
     1KS(2,2,1),FOLKS(2,2,2),EQUIP(2,2,1),EQUIP(2,2,2),EQUIP(2,3,1),EQUI
     2P(2,3,2),CR5/NOL
      PRINT 180, FOLKS(3,1,1),FOLKS(3,1,2),EQUIP(3,1,1),EQUIP(3,1,2),FAC
     1IL(3,1,1),FACIL(3,1,2),FOLKS(3,2,1),FOLKS(3,2,2),EQUIP(3,2,1),EQUI
     2P(3,2,2),CM5/NOL
      PRINT 190, FOLKS(4,1,1),FOLKS(4,1,2),EQUIP(4,1,1),EQUIP(4,1,2),FAC
     1IL(4,1,1),FACIL(4,1,2),CS5/NOL,FACIL(4,2,1),FACIL(4,2,2)
      PRINT 200, FOLKS(5,1,1),FOLKS(5,1,2),EQUIP(5,1,1),EQUIP(5,1,2),FAC
     1IL(5,1,1),FACIL(5,1,2),CO4/NOL
      PRINT 210, FOLKS(6,1,1),FOLKS(6,1,2),FACIL(6,1,1),FACIL(6,1,2),FAC
     1IL(6,2,1),FACIL(6,2,2)
C
C     PRINT TOTALS PER OPERATING LOCATION
C
      PEPOL=0.
      CPEPOL=0.
      CEQPOL=0.
      CFACOL=0.
      DO 30 I=1,6
      DO 30 J=1,5
      PEPOL=PEPOL+FOLKS(I,J,1)
      CPEPOL=CPEPOL+FOLKS(I,J,2)
      CEQPOL=CEQPOL+EQUIP(I,J,2)
      CFACOL=CFACOL+FACIL(I,J,2)
   30 CONTINUE
      PRINT 240, PEPOL,CPEPOL,CEQPOL,CFACOL
      PRINT 250, PEPOL*NOL,CPEPOL*NOL,CEQPOL*NOL,CFACOL*NOL
      PRINT 220, FOLKS(7,1,1),FOLKS(7,1,2),EQUIP(7,1,1),EQUIP(7,1,2),FAC
     1IL(7,1,1),FACIL(7,1,2),FOLKS(7,2,1),FOLKS(7,2,2),EQUIP(7,2,1),EQUI
     2P(7,2,2),CT3/NOL
      PRINT 230, EQUIP(8,1,1),EQUIP(8,1,2),EQUIP(8,2,2),EQUIP(8,3,2),EQU
     1IP(8,4,2),EQUIP(8,5,2)
C
C
C     MULTIPLY BY NUMBER OF OPERATING LOCATIONS
C
   40 DO 50 I=1,6
      DO 50 J=1,5
      DO 50 K=1,2
      FOLKS(I,J,K)=FOLKS(I,J,K)*NOL
      EQUIP(I,J,K)=EQUIP(I,J,K)*NOL
   50 FACIL(I,J,K)=FACIL(I,J,K)*NOL
```

```
C
C     COMPUTE TOTALS
C
      NPERS=PERSC=0.0
      DO 60 I=1,8
      DO 60 J=1,5
      NPERS=NPERS+FOLKS(I,J,1)
   60 PERSC=PERSC+FOLKS(I,J,2)
      EQUPC=0.0
      DO 70 I=1,8
      DO 70 J=1,5
   70 EQUPC=EQUPC+EQUIP(I,J,2)
      EQUPC=EQUPC+CL5+CR5+CM5+CS5+C04+CT3
      FACLC=0.0
      DO 80 I=1,8
      DO 80 J=1,5
   80 FACLC=FACLC+FACIL(I,J,2)
      TOTAL=PERSC+EQUPC+FACLC
      IF (PRINT) PRINT 260, NPERS,PERSC,EQUPC,FACLC,TOTAL
C     RESTORE SLMAX.
      SLMAX=SAVESLX
      RETURN
C
   90 FORMAT (/T10,28HOPERATING LOCATIONS REQUIRED,T40,I5/)
  100 FORMAT (T10,52HLAUNCH RATE DETERMINED BY RAID SIZE (LAUNCHES/HR/OL
     1),T90,F10.1/T10,81HLAUNCH RATE DETERMINED BY MAXIMUM SORTIES REQUI
     2RED/DAY TO DO JOB (LAUNCHES/HR/OL),T91,F9.1 /T10,50HMAXIMUM LAUNCH
     3 RATE REQUIRED (LAUNCHES/DAY/SYSTEM),T90,F10.1/)
  110 FORMAT (T10,27HHOURS/DAY BASE MUST OPERATE,T50,F10.2/T10,23HSHIFT
     1LENGTH (HR)-INPUT,T50,F10.2/T10,29HNUMBER OF SHIFTS/DAY RESET TO,T
     250,F10.2)
  120 FORMAT (6H FRAC=,F10.4)
  130 FORMAT (5H NTV=,E10.3)
  140 FORMAT (1H1,T10,8A10,T100,5HDATE:,A10,5X,5HTIME:,A10/T67,9HITERATI
     1ON,I5/)
  150 FORMAT (/T20,32HPERSONNEL PER OPERATING LOCATION,T61,32HEQUIPMENT
     1PER OPERATING LOCATION,T102,33HFACILITIES PER OPERATING LOCATION/T
     218,36(1H-),T59,36(1H-),T100,36(1H-))
  160 FORMAT (7H LAUNCH,T19,6HLAUNCH,T37,F4.0,F12.2,T60,9HLAUNCHERS,T78,
     1F4.0,F12.2/T19,14HLAUNCH CONTROL,T37,F4.0,F12.2,T60,11HACCESSORIES
     2,T78,F4.0,F12.2/T60,12HMOBILE EQUIP,T78,F4.0,F12.2/T60,7HRDT + E,T
     382,F12.2)
  170 FORMAT (9HORECOVERY,T19,8HRECOVERY,T37,F4.0,F12.2,T60,14HRECOVERY
     1AREAS,T78,F4.0,F12.2/T19,16HRECOVERY CONTROL,T37,F4.0,F12.2,T60,11
     2HACCESSORIES,T78,F4.0,F12.2,/T60,12HMOBILE EQUIP,T78,F4.0,F12.2/T6
     30,7HRDT + E,T82,F12.2)
  180 FORMAT (12HOMAINTENANCE,T19,9HPERSONNEL,T36,F5.0,F12.2,T60,16HTURN
     1AROUND EQUIP,T78,F4.0,F12.2,T101,15HMAINT BUILDINGS,T119,F4.0,F12.
     22/T19,11HREPAIR PERS,T36,F5.0,F12.2,T60,12HREPAIR EQUIP,T78,F4.0,F
     312.2/T60,7HRDT + E,T82,F12.2)
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190 FORMAT (8H0STORAGE,T19,9HPERSONNEL,T37,F4.0,F12.2,T60,14HHANDLING
   1EQUIP,T78,F4.0,F12.2,T101,12HCOLD STORAGE,T116,F7.0,F12.2/T60,7HRD
   2T + E,T82,F12.2,T101,13HREADY STORAGE,T116,F7.0,F12.2)
200 FORMAT (11H0OPERATIONS,T19,9HPERSONNEL,T37,F4.0,F12.2,T60,13HCONTR
   1OL EQUIP,T78,F4.0,F12.2,T101,16HCONTROL FACILITY,T119,F4.0,F12.2/T
   260,7HRDT + E,T82,F12.2)
210 FORMAT (11H0OL STARTUP,T19,8HSECURITY,T37,F4.0,F12.2,T101,14HMISS.
   1 FAC STOR,T113,F10.0,F12.2/T101,18HINITIAL ACTIVATION,T119,F4.0,F1
   22.2)
220 FORMAT (9H0TRAINING,T19,11HINSTRUCTORS,T37,F4.0,F12.2,T60,13HSPECI
   1AL EQUIP,T78,F4.0,F12.2,T101,17HTRAINING LOCATION,T119,F4.0,F12.2/
   2T19,8HTRAINEES,T35,F6.0,F12.2,T60,17HTRAINING VEHICLES,T74,F8.0,F1
   32.2/T60,7HRDT + E,T82,F12.2)
230 FORMAT (9H0VEHICLES,T60,11HACQUISITION,T74,F8.0,F12.2/T63,6HSPARES
   1,T80,F14.2/T60,7HRDT + E,T80,F14.2/T60,19HRECOVERABLE PAYLOAD,T80,
   2F14.2/T60,18HEXPENDABLE PAYLOAD,T80,F14.2)
240 FORMAT (/20H ** TOTALS PER OL **,T34,F7.0,F12.2,T78,F16.2,T119,F16
   1.2)
250 FORMAT (24H ** TOTALS FOR ALL OL **,T34,F7.0,F12.2,T78,F16.2,T119,
   1F16.2)
260 FORMAT (1X,135(1H-)/31H ** TOTALS FOR ENTIRE SYSTEM **,T34,F7.0,F1
   12.2,T78,F16.2,T119,F16.2//24H ** TOTAL SYSTEM COST **,T37,F16.2)
    END
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